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I.—Some Experiments on the Physiological Action of Uranium Salts. By R. H. Chittenden and Alexander Lambert, M.D.

In 1885, experiments were commenced in the laboratory of physiological chemistry at Yale University, to ascertain something regarding the physiological and toxical action of uranium salts. At that time there was little accurate knowledge concerning uranium. Gmelin* had, in 1824, performed a few experiments with the nitrate from which he concluded that this salt is a feeble poison; thus he states that 15 grains had no effect on a dog, that 1 drachm merely caused vomiting after more than an hour's interval, and that 34 grains killed a rabbit in 52 hours by stopping the irritability of the heart, while 8 grains injected into the jugular vein of a rabbit caused instant death. Later, in 1851, there appeared a statement in the British and Foreign Medico-chirurgical Review that Leconte always found sugar in the urine of dogs slowly poisoned by small doses of uranium nitrate. This statement was commented upon by Hughes in his *manual* of pharmico dynamics (p. 866), and has been made the basis of a claim by the so-called homœopathic school that uranium nitrate is a remedy for diabetes. Hughes also refers† to a monograph by Edward Blake on uranium, where three persons and nineteen animals were experimented on. In none of Blake's subjects, however, human or brute, was sugar eliminated in the urine. Ulceration of the pyloric end of the stomach and of the duodenum was found well marked in several of the animals, although in no case was the drug introduced directly into the stomach. Hughes, likewise, refers to several cases of diabetes which he considers were cured by the exhibition of small doses of uranium nitrate,‡ one-sixth to one-third of a grain three times a day. This constitutes all the matter bearing on uranium that we have been able to find.

Our work was commenced by a series of experiments on the influence of a variety of soluble uranium salts on the action of the amylolytic and proteolytic ferments occurring in the animal organ-

* Edinburgh Medical and Surgical Journal, vol. xxvi, p. 136.

† Ibid., p. 867

‡ Lancet, June 13, 1874.

ism. The results, already published,* show plainly that all of the uranyl salts, with one or two exceptions, have a more or less marked inhibitory influence on amylolytic and proteolytic action. With the salivary ferment, even 0·010 per cent. of uranyl nitrate was sufficient to completely stop all action, while with pepsin-hydrochloric acid and with alkaline trypsin solutions, 0·5 per cent. of the same salt was required to produce an equal effect. In this case the inhibitory action of the uranium salt was, in part at least, due to the formation of a more or less definite and indigestible compound of uranium with the proteid matter to be digested.†

On the excretion of carbonic acid, uranyl nitrate, by a later series of experiments,‡ was also found to have a marked influence. With rabbits, the hypodermic injection of this salt was followed by a slight rise in body temperature and a decided increase in the elimination of carbonic acid. The action of the salt was somewhat slow, but repetition of the experiment always led to an increase of body temperature and a decided increase in the amount of carbonic acid excreted. 0·7 gram of the salt in divided doses was required to produce the result stated, the rabbit not suffering any apparent ill effects from this quantity.

The object of the present series of experiments has been: 1st, to ascertain the influence of uranium salts on proteid metabolism; 2d, to ascertain something regarding the toxic action of uranium salts; and 3d, whether uranium has any influence on the production of glycosuria.

Influence on proteid metabolism.

In this experiment a mongrel bitch weighing 18·8 kilos was employed. The animal was confined in a convenient cage suitably arranged for the collection of the excreta, and was fed during the experiment upon a constant diet of known composition. A large quantity of fresh, lean beef finely chopped, was dessicated at a low temperature until it had lost about 75 per cent. of water. It then contained 11·88 per cent. of nitrogen, as determined by Kjeldahl's method. A large quantity of ordinary soda crackers were obtained and when sampled were found to contain 0·69 per cent. of nitrogen. 40 grams of this prepared beef and 25 grams of the crackers, with

* Chittenden and Hutchinson. Studies from the Laboratory of Physiological Chemistry, Yale University, vol. ii.

† See Chittenden and Whitehouse. Studies, vol. ii, p. 111.

‡ Chittenden and Cummins. Studies. vol. ii.

400 c. c. of water were fed to the animal twice daily, making a total daily income of 10·054 grams of nitrogen. As soon as nitrogenous equilibrium was established, the 24 hours' urine was analyzed for nine consecutive days, thus giving the average composition of the normal excretion. Uranyl nitrate was then administered for ten consecutive days in gradually increasing quantities.

The accompanying tables give the analytical results. Nitrogen was determined by the Kjeldahl method, sulphur and phosphorus by fusion of a given volume of the urine with potassium hydroxide and potassium nitrate in a silver crucible, and precipitation of the sulphur as barium sulphate and of the phosphorus first as phospho-ammonium molybdate and then as ammonio-magnesium phosphate.*

NORMAL URINE—Without uranium.

Date	Volume.	Re-action	Sp Gr.	Nitrogen	Sulphur.	Phos-phorus.	Dose of Uranyl nitrate.
May	c. c.			grams.	gram.	gram.	
31	565	acid	1016	8·414	0·441	0·572	0
June							
1	610	"	1017	10·380	0·516	0·687	0
2	630	"	1016	10·040	0·558	0·665	0
3	600	"	1018	9·618	0·589	0·595	0
4	630	"	1018	10·770	0·661	0 715	0
5	570	"	1019	10·325	0·608	0·632	0
6	460	"	1020	8·738	0·628	0·746	0
7	590	"	1018	10·091	0·576	0·712	0
8	640	"	1016	10·763	0·604	0·645	0·025 gram 0·025
Total	*5295*	...	....	*89·139*	*5·181*	*5·919*	
Daily average	*588*		*1017·5*	*9·904*	*0·575*	*0·657*	

Examination of the first table shows that the animal was in nitrogenous equilibrium, the average daily excretion of nitrogen for the normal period being 9·904 grams while the daily amount of nitrogen taken was 10·054 grams, thus showing a fairly close agreement, espe

* See studies from Laboratory of Physiological Chemistry, Yale University, vol. ii, p 88.

cially as there would be a slight loss of nitrogen through the hair shed daily. On commencing the administration of uranium nitrate, small doses were at first given two or three times daily in gelatin capsules, at times not to interfere with digestion. On the second day, uranium was detected in the urine. On June 12th, the 5th day the uranium salt was given, a trace of albumin appeared in the urine and on the day following, the 24 hours' urine contained 1·74 grams of albumin.

WITH URANIUM.

Date.	Volume.	Re-action.	Sp. Gr.	Total nitrogen.	Nitrogen—nitrogen of albumin.	Sulphur.	Phosphorus.	Dose of Uranyl nitrate.
June	c. c.			grams.	grams.	gram.	gram.	gram.
9	600	acid	1017	10·285	10·285	0·587	1·226	0·085, 0·085
10	600	"	1015	8·895	8·895	0·404	0·556	0·050, 0·025
11	602	"	1018	8·925	8·925	0·574	0·612	0·050, 0·025
12	680	"	1017	8·380	8·380	0·525	0·603	0·050
13	640	"	1022	11·391	11·093	0·724	0·621	0·025, 0·025, 0·025
14	710	"	1020	8·847	8·439	0·634	0·628	0·025, 0·050
15	720	"	1023	10·608	10·141	0·571	0·628	0·050, 0·050, 0·050
16	830	"	1022	11·767	11·446	0·738	0·704	0·075, 0·075, 0·075
17	640	"	1025	11·178	10·955	0·606	0·626	0·150, 0·150, 0·150
Total.	*6022*			*90·276*	*88·559*	*5·363*	*6·204*	*1·295* grams.
Daily average	*669*		*1019·9*	*10·031*	*9·839*	*0·596*	*0·689*	
18	650	acid	1026	10·179	9·772	0·611	0·543	0

On the 16th of June, the urine contained 7·7 grams of sugar. The appearance and disappearance of both albumin and sugar were followed quantitatively and the results will be discussed later on. Naturally, the appearance of albumin in the urine compels a correction in the table of nitrogen results on those days when albumin was excreted. This has been done by subtracting from the total nitrogen found, the nitrogen equivalent to the albumin, on the assumption that the latter contains 15·5 per cent. of nitrogen.

Examination of the analytical results shows that the uranium salt has a marked influence on the excretion of water, the increase amounting on an average for the nine days period to over 80 c. c. per day. There is also a very marked increase in the specific gravity of the daily excretion, but this is without doubt in great part due to the presence of albumin and sugar, as the increase is most noticeable on those days when the largest amounts of sugar and albumin were excreted.

Regarding nitrogen, a comparison of the total amounts excreted for the two periods, after correction for the nitrogen of the albumin, indicates that small doses of the uranium salt have little, if any, influence on proteid metabolism. On the last three days of the uranium period, however, when the amount administered had not only been increased, but there was doubtless also an accumulative effect, the excretion of nitrogen appeared to be considerably above the normal, certainly enough to warrant the assumption that comparatively large doses of uranium salts may increase somewhat proteid metabolism, and this view is sustained by the increase in both the total and daily average amounts of sulphur and phosphorus excreted. During the uranium period of ten days, 1·295 grams of the nitrate, or 19·98 grains, were given without any apparent ill effects being immediately produced.

Excretion of sugar and albumin.

After about 0·4 of a gram of uranium nitrate had been given, the urine began to show traces of albumin and five days after this, sugar made its appearance. The amounts excreted are shown in the accompanying table. Sugar was determined by Allihn's gravimetric method, and albumin by boiling with acetic acid and collecting the coagulum on a weighed filter. On the 18th, the weighed diet was discontinued, but the urine was kept under close scrutiny with the results shown in the table. The sugar first disappeared and four days after this the albumin, likewise. On again administering uranium, and in much larger doses than in the first series, both sugar and albumin failed to appear until after a single dose of over 4 grams of the salt had been administered, when considerable albumin showed itself in the urine. We were then compelled to stop the experiment, and the dog was chloroformed and a post-mortem immediately made.

The liver was excessively congested and appeared abnormally large. Microscopic examination of hardened sections showed an

TABLE SHOWING THE AMOUNTS OF ALBUMIN AND SUGAR IN THE DOG'S URINE.

Date	Volume	Reaction.	Sp Gr	Albumin	Sugar.	Dose of Uranyl nitrate.
June	c. c.			grams.	grams.	grams.
8	640	acid	1016	0	0	0·050
9	600	"	1017	0	0	0·070
10	600	"	1015	0	0	0·075
11	602	"	1018	0	0	0·075
12	680	"	1017	trace	0	0·050
13	640	"	1022	1·741	0	0·075
14	710	"	1020	2·684	0	0·050
15	720	"	1023	3·009	0	0·150
16	880	"	1022	2·066	7·735	0·225
17	640	"	1025	1·441	7·449	0·450
18	650	"	1026	2·633	7·476	0
		weighed	diet dis	continued.		
19	1280	acid	1016	3·604	14·887	0
20	-	"	- -	considerable	considerable	0
21*	750	"	1027	3·048	0·525	0
22	410	alkaline	1035	1·756	0	0
23†	.	acid	....	some	0	0
24	460	"	1018	0·578	0	0
25	430	alkaline	1030	trace	0	0
26	-	....	....	0	0	0
27		....		0	0	0·4
28	...	-	- -	0	0	0·5
29		-	....	0	0	0
30	- -	....	....	0	0	0
July 1		....		0	0	1·0
2		...	. ..	0	0	0
3	....	....	..	0	0	1·5
4	...	.. .	- -	0	0	4·4
5				considerable	0	0

infiltration of cells around the blood vessels, but aside from this and an apparent tendency of the liver cells to separate into stringy masses there was nothing abnormal. The kidneys both had adherent capsules and the medullary portion was large in ratio to the cortex, which, besides being smaller than normal, was striated. The lesion as made out microscopically was acute parenchymatous neph-

* On this day granular casts were found, but they were not present on the following day

† Dog vomited freely.

ritis. The endothelial cells of the malphigian tufts were swollen and proliferated, so that frequently the tuft of vessels was compressed by these proliferating cells and by the detritus and infiltrating pus cells. In the convoluted tubules the cells were swollen, granular and very much broken down, while the lumen of the tubes themselves was often filled with detritus and cast matter. In the straight tubules, the cells were also occasionally broken down and frequently swollen and granular. The stroma was found in places infiltrated with pus cells. Stomach and intestines were normal.

Further data regarding the excretion of albumin and sugar, through the action of uranium, are given in the description of the toxic action of this substance.

The toxic action of uranium.

Our experiments on the toxic action of uranium have been confined wholly to the action of pure uranyl nitrate on rabbits, nine in number. The animals were confined in cages with proper outlets for collecting the excreta, and were fed on grass, spinach, and other green food.

Experiment I.

Large, vigorous buck. In this experiment small doses of uranium, gradually increased, were given in gelatin capsules, and the urine examined each day for albumin and sugar. The accompanying table gives the details of dose and the amounts of sugar and albumin found.

Outside of changes in the urine there were no indications of toxic action until on the ninth day, when a slight weakness was noticeable, especially in the hind legs. After this, the animal gradually grew weaker and emaciated, with total loss of appetite and with eyes dull and watery. On the 8th of June, a large quantity of thick tenacious mucus mixed with pin-head fæces was passed. Motion of all kinds was difficult. On the 9th of June, the animal could not sit up and during portions of the day there appeared to be paralysis of both hind legs. Later in the day the power of motion returned, and when placed on his back the rabbit could kick out feebly with both legs. On the next day his weakness and dullness were still more pronounced, and when stirred from a squatting posture he trembled violently. His eyes were watery and glazed, with the pupils widely dilated. On touching the cornea he did not offer to close the eyelids, but endeavored to withdraw his head. All power of vision was apparently lost. Later, he lost the power of coördination in his legs, was unable to make any coördinate movements, though still retaining

the power to move each limb separately. All fæcal discharges had stopped and the animal refused all food.

Date.	Volume.	Reaction.	Sp. Gr.	Albumin.	Sugar.	Dose of Uranyl nitrate.
May	c. c.			gram.	gram.	gram.
25	78	alkaline.	1020	0	0	0·025
26	—	"	—	0	0	0·050 0·025
27	70	"	1020	0	0	0·050
28	85	"	1016	0	0·035	0·050
29	75	"	1022	0·189	trace.	0·050
30	—	—	—	—	—	0·050
31	75	"	1023	0·140	0·492	0·050 0·025
June 1	82	"	1028	0·125	0	0·050 0·050
2	75	"	1021	0·101	0	0·050 0·050
3	80	"	1020	0·173	0	0·050 0·050
4	18	neutral.	—	0·217	0	0·050 0·050
5	12	alkaline.	—	0·155	0	0·050
6	—	—	—	—	—	0·100
7	45	"	1025	0·518	0	0·100 0·100
8	30	"	—	0·301	0	0·150 0·150
9	20	"	—	considerable.	0	0·200 0·200
10	0					0·200 0·150
						2.175 grams.

On the morning of the 11th found dead. Post-mortem showed the heart distended on the right side and the lungs normal. The liver was much smaller than normal and the gall-bladder full of very black bile. On a microscopic examination of the liver, the only noticeable feature was the extreme congestion. In the stomach, the mucous membrane seemed somewhat disintegrated. In the intestines, brown colored spots were seen where Peyer's patches are situated, and microscopic examination showed that the latter were deeply inflamed. Further, from the large amount of mucus in the mucous glands, it was evident that there was acute catarrhal inflammation of the intestines. The cæcum was full of black matter. There were no normal fæces in the colon or rectum, only the pin-head variety.

The kidneys were very much diminished in size and extremely congested. Sections showed that the epithelial cells of the malpighian tufts were not swollen or proliferated, though in some places the tufts of vessels were slightly compressed by detritus. The cells of the convoluted tubules were swollen, granular and broken down or gone entirely, as were also the cells of the straight tubes, the latter being also filled in places with casts and detritus. The vessels between the tubes were filled with blood The stroma was swollen and infiltrated with pus cells and in places there were extravasations of blood.

Brain and cord were slightly congested, but otherwise normal.

Examination of the table of urine tests shows that sugar appeared first in the urine, but continued only for three days, while albumin showed itself immediately after the first appearance of the sugar and continued throughout the experiment. The amount of urine voided grew gradually smaller as the animal began to feel the full effects of the uranium.

Experiment II.

In this experiment, uranium was given as indicated in the following table, and the urine examined each day.

Date.	Volume.	Reaction	Sp Gr	Albumin	Sugar	Dose of uranyl nitrate
June	c. c.			gram	gram.	gram.
1	—	alkaline.	—	0	0	0·050
2	100	"	1014	trace.	0	0·050 0·050
3	55	"	1025	0·192	0	0·050 0·050
4	41	"	—	0·227	0·406	0·050 0·050
5 6	125	acid.	1024	1·095	1·078	0·050 0·050
7	120	alkaline.	1024	0·528	0·917	0·050 0·050
8	100	acid.	1022	0·237	trace.	0·100 0·100
9	55	alkaline.	—	0·351	0	0·100 0·100
10	125	"	1022	0·687	0·480	0·100 0·100
11	75	"	—	considerable.	0	0·100
12	75	"	1022	0·382	0	0·100
						1.350 grams.

On June 4th, the animal began to show weakness, particularly noticeable in his hind legs, but this disappeared and the animal

appeared better. On the 11th, it had lost its appetite, become emaciated and showed general weakness and loss of muscular power. On the following day at noon it was found dead, without having shown any marked symptoms other than general depression of the muscular system.

The heart was found greatly distended on the right side, lungs normal and the liver small and congested, especially near the lower edges of the left lobe. Kidneys were also small and congested. The bladder contained quite a little urine, with considerable albumin and sugar in it.

Experiment III.

This experiment was practically a duplicate of the preceding. An albino buck was used and the uranium salt was forced down the throat in gelatin capsules, as in the preceding experiments. The table shows the amount of nitrate given and the character of the urine each day.

Date.	Volume	Reaction	Sp. Gr.	Albumin.	Sugar	Dose of uranyl nitrate
May	c. c.			gram.	gram.	gram.
25	171	alkaline.	1014	0	0	0·025
26		acid.	—	trace.	0	0·050 0·025
27 28	no urine passed					0·050
29 30	75	alkaline.	1026	0·494	0.275	0·050 0·050
31	no urine passed.					0·050 0·025
						0·800 gram.

The first symptom noticeable was the suppression of urine for over forty-eight hours. On the 27th, the animal was quite dull and showed signs of general weakness. As he walked, he moved as if it caused him pain in the lumbar region. On the next day he showed great thirst, and he finally died on June 1st, a loose diarrhœa setting in a few hours before death.

Post-mortem examination showed that the heart had stopped in diastole, and that it was much distended with blood. Lungs were normal. The liver was congested, as were also the kidneys. The latter had non-adherent capsules. The stomach contained considerable undigested food, and its mucous membrane was partly disintegrated. Portions of the duodenum were somewhat congested. The

bladder contained a few cubic centimeters of urine, which had in it considerable sugar and some albumin.

The most noticeable feature of this experiment was the suppression of urine.

Experiment IV.

In this experiment, a large white buck was used and the uranium was administered in capsules as follows:

May 17	0·050	gram uranyl nitrate
18	0·075	" " "
19	0·075	" " "
20	0·025	" " "
	0·225	

There were no symptoms of toxic action until the morning of the 20th The rabbit was then dull and weak. He trembled violently as he hopped about; the hind legs appeared partly paralyzed. The pupils were dilated and the appetite gone On the 21st, weakness was still more pronounced. Any movement was accompanied by tremblings and great difficulty was experienced while walking, in making the different movements correctly. There was severe diarrhœa and the animal showed extreme emaciation. On the 22d, the diarrhœa had passed into an involuntary defecation more or less continuous. The animal was too weak to move and lay all the forenoon breathing heavily, though the number of respirations per minute did not go much beyond normal, 45–54 per minute. On the afternoon of this day, two days after the last dose of uranium had been administered, the animal appeared stronger, the involuntary defecations had ceased, though a loose diarrhœa still continued, and the animal appeared to have recovered the use of its locomotive muscles. On the 23d, however, the animal was again unable to move and finally died at noon, the diarrhœa having continued more or less up to death

During the last three days there was complete suppression of urine, but on the 20th, 59 c. c. of urine were passed, of specific gravity 1022, and which contained 0·656 gram of sugar.

On post-mortem examination, the heart was found to have stopped in diastole and engorged with blood. The lungs were congested. The kidneys had non-adherent capsules and the cortex and medulla showed severe congestion. The stomach contained no food, but considerable tenacious mucus. The small intestines from duodenum to cæcum were very much congested.

Experiment V.

Gray and white buck. This experiment was a repetition of No. IV, the same amounts of uranium salt being given and at the same intervals of time. The animal died three days after the last dose of uranium had been administered. The symptoms were not very marked, simply loss of muscular power, and a gradual wasting away. On post mortem, the heart was found in diastole and engorged with blood. Lungs congested. The liver was black with the blood in it, especially on the edges, and when pressed between the fingers was extremely pliable and of a soft, pulpy consistency, showing marked parenchymatous degeneration. The gall bladder was distended with very dark bile. Both kidneys had non-adherent capsules. The left kidney was slightly congested. The intestines had an inflamed patch in the jejunum and were congested for a foot above it. The bladder contained a little urine, which gave reactions for both sugar and albumin. Sugar and albumin were also found in the urine several days before death.

Experiment VI.

In this experiment still smaller amounts of uranium were administered, a total of only 0·175 gram being given in three days. The following table shows the dosage and the changes in the urine:

Date.	Volume.	Reaction.	Sp. Gr.	Albumin	Sugar.	Dose of uranyl nitrate.
June	c. c.			gram.	gram.	gram.
14	—			0	0	0·050
15	—	alkaline	1048	0	0	{ 0·050 0·025
16	110	"	1027	0·104	0	0·050
17	75	"	1022	0·387	0	
18	80	"	--	0·126	0	0·175
19 } 20 }	60	"	—	0·154	0	
21	—	"	—	some	0	
22	50	"	1015	trace	0	

There were no noticeable symptoms of toxic action aside from the changes in the urine, and even here there was no sugar at any time present. Just as the albumin had almost disappeared from the urine and we looked for speedy recovery, the animal was found dead (on the 23d). Post-mortem showed the heart in diastole, engorged with blood. Lungs normal. Liver normal, aside from a slight congestion.

Sections under the microscope showed no pathological changes. The kidneys were congested. Under the microscope, the epithelial cells were proliferated and occasionally the tufts were seen slightly compressed by these proliferating cells and detritus The convoluted tubules showed swollen and granular cells, even broken down, in places. In the straight tubules, the cells were also swollen and granular and sometimes were detached from the tubes. In places, there was cast matter and detritus in the tubes. The stroma was normal. Hence, here, as in many of the preceding experiments, it is a case of acute parenchymatous nephritis. The stomach was full of undigested food and apparently normal; the duodenum was congested and the small intestines throughout were nearly empty, except for a little mucus. The bladder had in it about 10 c. c. of urine, which contained a trace of albumin but no sugar.

Experiment VII.

An albino rabbit. A single dose of 0·3 gram of uranyl nitrate was given in a gelatin capsule by mouth on June 13th. Outside of changes in the urine there were no symptoms whatever until the 17th, when in the early morning the animal was found weak and powerless, all motor power completely gone. It rapidly grew weaker and died in the afternoon of the same day.

The right side of the heart was found much distended. The lungs were normal, the liver small and congested. Kidneys were also small and congested and of a cloudy appearance. Microscopic examination showed acute parenchymatous nephritis. Stomach was full of undigested food, but the intestines were empty. Both appeared normal.

On June 15th, 160 c. c. of alkaline urine were passed, of specific gravity 1023. It contained 0·748 gram of albumin and 1·069 grams of sugar. On the 16th, 30 c. c. were passed of 1022 specific gravity and containing 0·412 gram of albumin and 0·354 gram of sugar. On the 17th, no urine was passed and on making the post mortem the bladder was found empty.

With this rabbit, an attempt was made to ascertain how much carbohydrate matter there was in the liver at the time of death. 40 grams of the sampled and finely ground liver were thoroughly extracted with boiling water (continuous extraction for three days), frequently replaced. The several decoctions were ultimately united and finally brought to a volume of 500 c. c. Two portions of 200 c. c. each were placed in suitable flasks and sufficient hydrochloric acid

added to each, to make the fluid contain 2 per cent. HCl. The acid fluids were then heated on water-baths for 15 hours, in order to convert all carbohydrate matter into dextrose. The fluids were then neutralized, evaporated and finally tested for dextrose with Fehling's solution, by Allihn's gravimetric method. Both solutions failed to give any reducing action whatever, thus showing a total lack of carbohydrate matter in the liver. This is in strong contrast to the normal condition of a rabbit's liver, which contains an abundance of carbohydrate matter, both sugar and glycogen; on an average 10·35 per cent. of total carbohydrates, as determined by methods similar to the one just described.* Glycogenic function is then destroyed by uranium, the same as in phosphorus poisoning, but unlike the action of phosphorus there is apparently no fatty degeneration of the organs.

The liver here experimented with was small for the size of the rabbit, a large white buck. It was also noticeable, as in many of the other rabbits experimented on, that while the stomach was full of food, sometimes even distended by it, there was nothing at all in the intestines below the pylorus until the cæcum was reached, which was again full, and the intestines below were either almost free from fæces or else contained only the pin-head variety. The food in the stomach was wholly undigested. As has been already pointed out, a small percentage of a soluble uranium salt is sufficient to completely stop gastric and pancreatic digestion. This being the case it is quite probable that the emaciation, etc., so noticeable in uranium poisoning, is the direct result of the action of the salt on the digestive functions. Nothing being digested there would be no matter for absorption, and hence no sugar-forming material for the liver. All the carbohydrate matter stored up would in a little time be completely consumed and as the portal blood could bring no new nutritive matter, the liver would naturally diminish in size and the animal become emaciated and eventually die from that cause alone, even if the uranium gave no other direct cause of death. In this connection we also need to recall the general increased metabolism of both nitrogenous and non-nitrogenous matter, under the influence of uranium.

The uranium salt may also act specifically on the liver cells, affecting their metabolic power, preventing any storage of carbohydrate matter or more probably causing a degeneration of the cells, by which they may be led to give up to the blood in abnormal abundance all the carbohydrate matter previously stored up. This possible

* Post-mortem formation of sugar in the liver. Studies from Laboratory of Physiological Chemistry, Yale University, vol. 1, p. 171.

specific action of the poison on the liver cells would in a measure explain the temporary glycosuria, which appears and then disappears so frequently in uranium poisoning. Further, by a combination of this specific action with the non-absorption of nutritive matter through retarded digestion, it would be easy to explain the alternate appearance, disappearance and re-appearance, of sugar in the urine in these cases. Where the symptoms run their course with a fair degree of rapidity, as in continued dosing with uranium, sugar appears in the urine for a few days and then disappears, although the amount of uranium administered may be steadily increased. In fact, the increased dose of uranium is doubtless the cause of the further non-appearance of the sugar, since the stored up carbohydrate material having been wholly used up, and at the same time digestion and absorption being prevented, there is no more carbohydrate-producing material available, either directly or indirectly. On the other hand, if, after the sugar at first present has disappeared from the urine, there comes an interval of a day or so when uranium is not administered and digestion again starts up, then the specific action may again come into play and a temporary glycosuria again result. This condition was noticed in experiment No. II.

In some of the experiments, there seems to have been a visible change in the hepatic cells, as in the experiment next to be described, where under the microscope the cell bodies appeared as if collected into small granules or even broken down. Again, in some experiments, as in No. V, there was a noticeable pulpy degeneration of the liver cells.

Experiment VIII.

In this experiment, the uranium salt was introduced by hypodermic injection. 0·23 gram of uranyl nitrate in a little water was injected beneath the skin of the leg of a good-sized rabbit, on June 20th at 4.0 P. M. Two days after he showed marked weakness, although his appetite remained good. On the following day he appeared quite dormant and could be roused only with difficulty; power of motion seemed to be nearly gone. He died the next day at noon. On June 21st, the day following the administration of the uranium, 60 c.c. of alkaline urine were passed containing 0·234 gram of albumin and 0·660 gram of sugar. After this, there was complete suppression of urine till death.

Post-mortem.—Heart had stopped in diastole; lungs normal. The liver was mottled and congested slightly in areas. Under the micro-

scope, sections showed the cell bodies strongly granulated, with their outlines mostly clear, but in places broken down.

There was also an infiltration of pus cells around the blood vessels. The kidneys were normal in size and appearance, with non-adherent capsules Under the microscope, however, all the conditions characteristic of acute parenchymatous nephritis were to be seen. The epithelial cells of the malpighian tufts were proliferated, so much so as to compress the vessels. Both convoluted and straight tubules had their cells swollen, granular and broken down. The stroma was normal. Some adipose tissue in the pelvis of the kidney was infiltrated with pus cells. There was also considerable detritus between the papillæ. The bladder was empty and contracted. In the abdominal cavity there was about 30 c.c. of a coagulable, clear fluid. The stomach was full of food, the intestines empty. No fæces in colon and rectum. No signs of congestion in the alimentary tract, except in the rectum, where there were red blotches which proved to be the beginning of inflammation and infiltration of pus cells. The animal appeared to have died from suppression of urine.

Experiment IX.

In this experiment, one large dose of uranium (1·0 gram of the nitrate) was given by mouth on June 27th, at 4.30 P. M. On July 5th. the animal was still alive, but weak and emaciated. There were no symptoms other than those already described. Owing to lack of time we were not able to continue the experiment, but wishing to see any changes which might have occurred in the organs the animal was chloroformed and a post mortem made. On June 28th, the urine passed contained some albumin, but no sugar; on July 1st, considerable albumin, but still no sugar.

The liver was found to be small but not congested. The cell substance, as seen under the microscope, was collected into small granules. Nuclei and nucleoli were quite distinct. Kidneys had non-adherent capsules, but they were congested and the cortex looked striated. Under the microscope, the epithelial cells of the glomeruli were seen to be swollen and proliferated. In the convoluted tubes, the cells were slightly swollen and granular and occasionally broken down. The straight tubes were also broken down in places and contained cast matter. The stroma was normal. Stomach was filled with food, while the intestines were entirely empty. Peyer's patches were swollen and infiltrated with pus cells. The cæcum was partially filled with matter and the end of it looked honey-combed. It

proved to be slightly inflamed, and with cells infiltrated into it more or less. Colon and rectum were empty.

From these results, collectively, it is to be seen that uranium is an irritant poison and, like other metallic irritants, produces gastro-intestinal irritation of more or less intensity, as shown by the acute diarrhœa and other symptoms met with in this form of poisoning. In the majority of cases, the action of the uranium salt on the intestines results in a simple enteritis, but this is liable to pass eventually into acute catarrhal inflammation.

As ordinarily administered, it is not in any sense a rapid poison; the ingestion of a fatal dose of a uranium salt is not followed by any noticeable effects for some time. The action of a small amount (150 milligrams) is apparently as rapid and pronounced as that of large quantities (1 gram). The first noticeable symptom in rabbits is general weakness, lack of motor power, loss of coördination and occasional temporary paralysis of the locomotor muscles. Introduced into the stomach in sufficient amounts, it checks digestion and even stops it altogether. On the other hand, it appears to increase somewhat proteid metabolism and also to increase the elimination of carbonic acid and raise the body temperature. Hence, it is to be considered as having a direct action on nutrition, the disturbance of which is also plainly indicated by the rapid emaciation which follows the administration of uranium.

Its most marked lesions are its destructive action on the kidneys, and its destruction of the kidney tissue itself. It causes here an acute parenchymatous nephritis of the same kind as found in arsenic, mercury, and phosphorus poisoning. Further, the quantity of albumin found in the urine shows plainly how greatly the blood vessels are involved in the inflammation. The albuminuria produced is severe and constant, and when the uranium is given in a single large dose, as in experiment No. IX, or in a small dose by hypodermic injection, as in experiment No. VIII, then albumin may appear in the urine within 24 hours. The uranium must have some specifically destructive action on the kidney epithelium cells, causing them to swell and break down. At first, with small doses of uranium, the urine is decidedly increased in volume, but later on, when toxic action is more pronounced, there may be a partial or even complete suppression of the urine. This latter condition is naturally more quickly produced by large doses of uranium. In several cases, suppression of urine would seem to have been the cause of death. The urine, too, in a short time after the admin-

istration of uranium contains more or less sugar; as a rule the sugar does not make its appearance until after the albumin. Salkowski has shown that mercury will also cause diabetes in rabbits, but it is questionable whether it is as constant a symptom as in uranium poisoning. It is also stated that in phosphorus poisoning the urine sometimes contains sugar.* In the hypodermic injection of uranium, experiment No. VIII, sugar appeared in the rabbit's urine within 24 hours. The production of glycosuria is a very characteristic symptom in uranium poisoning. The urine also contains invariably a large amount of crystallized calcium oxalate, which would also point to decided malnutrition and help explain the marked emaciation so commonly seen.

In those cases where the poisoning becomes in a measure chronic, the nervous symptoms sometimes predominate, as shown in loss of sight and power of coördination.

* H. C. Wood Therapeutics, p 110.

II.—ELASTIN AND THE ELASTOSE BODIES. BY R. H. CHITTENDEN AND HORACE S. HART, B.A., PH.B.

ELASTIN, the basis of the so-called elastic tissue, has generally been considered one of the most indigestible of the albuminoid substances. In fact, the older writers looked on it as almost insoluble in the digestive juices. Recently, however, the experiments of Etzinger,* Horbaczewski,† and Morochowetz,‡ have shown that both the *ligamentum nuchæ* of the ox when finely divided, and purified elastin when powdered, are fairly soluble both in pepsin-hydrochloric acid and in natural gastric juice, as Horbaczewski's observations on a man with stomach fistula have fully indicated.

It has been our object, therefore, to study somewhat in detail the primary cleavage products of elastin, so far as they may be formed, making use of the methods§ which have yielded such fruitful results with many of the proteid bodies.

Preparation of Elastin.

As usually described, elastin is a body free from sulphur, insoluble in water even after several days boiling, likewise in cold dilute alkali, acetic acid, dilute hydrochloric acid, alcohol, and ether. Naturally, therefore, the method of preparing such an insoluble body has consisted in removing from a tissue rich in elastin, all extraneous substances by successive treatment with the above-mentioned reagents. In fact, so vigorous is the method of treatment, as usually described, that it appears almost questionable whether a body belonging to a group noted for ease of decomposition might not suffer some change in such a long process of preparation.

We have employed two methods, the first one of which is practically identical with that followed by Horbaczewski. The neck bands of a number of recently killed oxen were thoroughly freed from all adhering fat and muscle and then chopped quite fine; they weighed

* Zeitschrift für Biologie, Band x, p. 84.

† Ueber das Verhalten des elastins bei der Pepsinverdauung, Zeitschrift fur physiologische chemie, Band vi, p. 330.

‡ Verdauungsgesetze, Abstract in Jahresbericht für Thierchemie, 1886, p. 271.

§ Kühne and Chittenden, Zeitschrift für Biologie, Band xx, xxii, also Studies from Laboratory of Physiological Chem. Yale University, vol. ii.

2400 grams. The mass was boiled for four days in water frequently changed, after which it was soaked for 45 hours in 8 litres of 1 per cent. potassium hydroxide, and then boiled with the solution for 4 hours. The tissue was freed from alkali by thorough washing with water, and was then boiled with water, frequently changed, for 16 hours. The potassium hydroxide solution on neutralization, gave a heavy precipitate slightly soluble in excess of 0·4 per cent. hydrochloric acid, easily soluble in strong acid. The addition of acid in excess caused a strong odor of hydrogen sulphide to be given off.

After boiling the tissue a second time with water, it was placed in 8 litres of 10 per cent. acetic acid and warmed for an hour and a half, after which it was allowed to stand in the cold for 16 hours. It was then boiled for 4 hours in the same acetic acid solution, and afterwards washed thoroughly with water. The tissue was then placed in 10 litres of 5 per cent. hydrochloric acid and allowed to soak for some time in the cold, after which it was washed in running water and macerated in water, frequently changed, for 24 hours to take out all traces of the acid. After this treatment, the tissue was boiled with successive portions of water for about 45 hours, when it was placed in a large volume of 95 per cent. alcohol and allowed to remain for several days. It was afterwards boiled in alcohol for about 15 hours and then placed in an excess of ether, after which it was extracted with warm ether for two days.

ANALYSIS OF ELASTIN A.

No.	Substance used. gram	H_2O found gram	H %	CO_2 found gram	C %	N found c. c	T C.	Pressure mm	N %	Ash found gram	Ash %
I	0·4250	0·2745	7·17	0·8381	53·77				...	....	..
II	0·3898	0·2218	7·28	0·6697	53·74	..		...		.	
III	0·5454	..	..	..		72·7	8·6	771·5	16·47	....	...
IV	0·4440	....	....	. .	....	59·8	9·0	771·2	16·59	...	. .
V	0·5125	.		.		69·4	9·4	767·1	16·59	...	..
VI	0·2971		..	....	.	..	. .	...	....	0·0027	0·9

Percentage composition of ash-free substance:

						Average.
C	54·26	54·22	.	....	....	*54·24*
H	7·24	7·30		....	...	*7·27*
N	. .	.. .	16·74	16·76	16·62	*16·70*
O	....	....	....	....	.. .	*21·79*
						100·00

The tissue on being freed from water was hard, tough, and difficult to powder. It was finally ground to a coarse powder and then re-extracted with warm ether, until the ether on evaporation left no appreciable residue. This took some time, for, as previously pointed out by Horbaczewski, there apparently remains in the tissue a small amount of fat-like matter, which dissolves very slowly in ether and which can be completely extracted only by first grinding the purified tissue as fine as possible. The elastin prepared in this manner we have termed for convenience *Elastin A*.

A portion of the preparation dried at 110° C. gave on analysis the results contained in the accompanying table. The methods of analysis were the same as those previously described in former articles on the proteoses.* By fusion with potassium hydroxide and potassium nitrate, according to the method recommended by Hammarsten,† no sulphur could be found. Elastic tissue, however, unquestionably contains sulphur, but whether it exists there as a constituent part of the elastin molecule, or loosely united as in keratin, or as a constituent of some adhering proteid or other substance, it is difficult to say. Certainly, the boiling of elastic tissue with 1 per cent. potassium hydroxide for several hours might reasonably be expected to remove a part at least of any sulphur which might be present, and if by this process sulphur is removed from the tissue might it not as probably come from the elastin, as from any other proteid substance? Treatment with acid, of the alkaline solution obtained in the preparation of *A*, plainly showed the presence of hydrogen sulphide and we therefore decided in the preparation of the second portion of elastin to omit the treatment with alkali. Accordingly, 1700 grams of carefully cleaned neck bands from oxen were treated in the same manner as in *A*, except that the alkali was omitted, and in its place, treatment of the tissue with both acetic and hydrochloric acid was repeated twice. In subjecting elastin to the action of 5 per cent. hydrochloric acid care must be taken, before boiling the washed tissue with water, to see that every trace of acid is removed, otherwise the faintly acid water formed will at 100° C. give rise to a partial decomposition of the elastin.

After thorough extraction of the powdered elastin with ether, a portion dried at 110° C. gave by analysis the results shown in the following table, *Elastin B*.

* See Zeitschrift für Biologie, Band xx, p. 11, and Amer. Chem. Jour., vol. vi, p. 3.
† Zeitschrift für physiologische Chemie, Band ix, p. 298.

Analysis of Elastin B.

No	Substance used. gram	H_2O found gram.	H %	CO_2 found. gram.	C %	N found. c. c.	T. °C.	Pressure. mm	N %	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	Ash found. gram.	Ash %
I	0·5833	0·3744	7·18	1·1531	53·90	....	....	....	-	....	....	....	....
II	0·4374	0·2851	7·24	0·8658	53·94	..	....	-		....	....	....	....
III	0·3836	....	....	....	....	54·1	11·0	754·8	16·91	....	....	....	....
IV	0·4821	....	....	....	....	66·8	11·7	760·4	16·69	....	....	....	....
V	0·9095	..	....	....	....	-	....	....	....	0·0170	0·25	....	....
VI	0·7854	..	....	....	....		...	....	-	0·0208	0·36	....	....
VII	0·4235	....	....	....	....	....	....	....	- -	....	- -	0·0015	0·35
VIII	0·4583	...	....		. .	...	-	...	...	....	...	0·0018	0·28

Percentage composition of ash-free substance:

							Average.
C	54·06	54·10	..	..		....	*54·08*
H	7·15	7·26	..	....	-	....	*7·20*
N	..	....	16·96	16·75	...	...	*16·85*
S	..	.	...	....	0·34	0·29	*0·30*
O	..	...	...	....	...	....	*21·57*
							100·00

Comparison of the two products shows a fairly close agreement in composition. In *B*, however, the carbon is slightly lower and the nitrogen a trifle higher than in *A*. Further, Elastin *B* contains 0·3 per cent. of sulphur, as determined by the modified Liebig's process.* Müller originally reported elastin, purified, however, by the use of an alkali, as containing 0·08 per cent. of sulphur, but this he considered merely as an impurity.

Morochowetz, who appears to have made a hydration product of elastin by the simple action of heat and water, states that it contains 0·617 per cent. of sulphur, but the details of his process we do not know.† If the figures are correct, his elastin must have probably contained double the percentage of sulphur present in elastin *B*. Whether pure elastin does contain sulphur, or whether the 0·3 per cent. present in preparation *B* is simply a constituent of some adhering proteid, removable by alkali, we are not at present prepared to say, but deem it probable that elastin does contain a small amount of sulphur.

* See studies from Laboratory of Physiological Chemistry, Yale University, vol. ii, p. 163.

† We have seen only an abstract in Jahresbericht für Thierchemie für 1886, p. 271.

Elastin *A*, prepared by the usual process, shows a close agreement in composition with Horbaczewski's product, but is quite different from the product obtained by Müller and Tilanus, as seen from the following table.

	Elastin A.	*Horbaczewski.*	*Muller.**	*Tilanus.**
C	54·24	54·32	55·09–55·72	54·90–55·65
H	7·27	6·99	7·11–7·67	7·25–7·41
N	16·70	16·75	15·71–16·52	17·52–17·74

The higher content of carbon in the preparations of Müller and Tilanus are doubtless due to the presence of more or less fat, not completely extracted by ether.

Decomposition of Elastin by acid water at 100° C.

On heating moist elastin with water containing a trace of hydrochloric acid, for some hours at or near 100° C. it soon commences to swell, and after a time becomes converted into a semi-gelatinous mass, a portion of which, as the boiling continues, becomes soluble and passes into the acid fluid. The liquid gives no reaction with tannic acid for gelatin, but does give a strong biuret reaction and yields a heavy turbidity when excess of strong potassium hydroxide is added to the solution. Evidently, under these conditions, some soluble cleavage product or products are formed, percipitable by excess of caustic alkali.

These products we prepared in quantity by taking a portion of elastin *A*, soaking it for some time in 5 per cent. hydrochloric acid, until the softened elastin was thoroughly impregnated with the acid, then washing out the excess of acid by soaking it for 20 hours in a large volume of water. The elastin, still quite strongly acid to test papers, was then boiled in water for about 10 hours, when the acid liquid was strained off from the gelatinous elastin. The boiling was then continued with a fresh volume of water, the gelatinous mass still containing sufficient acid to render the whole fluid distinctly acid to test papers. This process was repeated until the elastin had been heated for 45 hours with water gradually containing less and less acid, until finally the elastin remaining had entirely lost its former gelatinous appearance and taken on its original look. All of the acid fluids were united and concentrated somewhat,

* Gorup-Besanez, Physiologische Chemie, Dritte Auflage, p. 148

then neutralized with sodium carbonate. No neutralization precipitate was observed. By further evaporation of the neutral fluid on a water-bath, a gummy mass separated on the bottom of the dish. It was quite tenacious, something like rubber, soluble in cold water, but not so readily in hot. The cold water solution of the gummy mass, and the mother-liquor showed the following reactions:

1. Heated in a test-tube, the solution quickly became turbid, giving finally, if concentrated, a sticky precipitate. The turbidity, however, immediately disappeared as the fluid cooled, returning again when heat was applied and disappearing when cold. When the solution was so concentrated as to yield a heavy precipitate by heat, it naturally dissolved more slowly.

2. With chloroplatinic acid, a heavy yellow precipitate was formed, readily soluble in alcohol.

3. Heated with acetic acid there was no change, but addition of potassium ferrocyanide to the acid fluid caused a heavy precipitate.

4. Millon's reagent gave a strong reaction similar to the albumin reaction.

5. Strong potassium hydroxide gave a fine flocculent precipitate, insoluble in excess of the alkali.

6. Pure dilute nitric acid gave a heavy precipitate, only slowly soluble in excess of the acid. Heated, it yielded a clear yellow fluid and with ammonia gave the orange yellow color of the xanthoprotein reaction.

7. Pure dilute hydrochloric acid yielded a slight precipitate, soluble in large excess.

8. Saturation of the solution with ammonium sulphate gave a heavy, gummy precipitate

The gummy mass and the original filtrate giving approximately the same reactions, the solution of the former was united with the latter, the fluid made slightly acid with acetic acid and then saturated in the cold with ammonium sulphate. The saturated fluid, on being boiled, gave a second gummy precipitate which was added to the first.

From analogy with the reactions of the proteoses, ammonium sulphate should precipitate any elastose bodies formed, leaving in solution the true peptone. The precipitates formed in the manner described were washed by being rubbed up in a mortar with hot saturated ammonium sulphate solution, and the washings added to the filtrate. A portion of the ammonium sulphate was then removed from the solution by concentration and crystallization, and the remainder by dialysis in running water. On testing the solution for peptone, however, none could be found; the biuret test failed to give any reaction, as did also phosphotungstic acid.

Protoelastose.

The ammonium sulphate precipitate of elastoses, after being washed as described above, was dissolved in water, the solution made quite neutral by addition of a little sodium carbonate and then saturated with crystals of rock salt. A heavy gummy precipitate resulted, which by analogy should consist of what we may call protoelastose.

This precipitate, after being washed with saturated salt solution, was dissolved in water and reprecipitated by salt, this process being repeated three times. The final sodium chloride precipitate was dissolved in water, dialyzed until all chlorine was removed from the solution, concentrated and precipitated with 95 per cent. alcohol. Apparently, only a portion of the substance was precipitated by alcohol, so the alcoholic filtrate was evaporated and the residue carefully dried. Further examination, however, showed that both products were identical, alcohol simply precipitating a portion of the substance.

After being dried at 110° C. until of constant weight, having then the form of a brown powder, both products were analyzed with the results shown in the accompanying tables.

ANALYSIS OF PROTOELASTOSE (A1) PRECIPITATED BY ALCOHOL

No.	Substance used. gram	H_2O found gram	H %	CO_2 found gram	C %	N found. c. c.	T. °C	Pressure. mm.	N %	Ash found gram	Ash %
I	0·6852	0·4271	6·92	1·3190	52·49	....	....	-	....	- -	
II	0·3936	0·2437	6·89	0·7536	52·27	...	....	...	...	...	
III	0·5400	...	..	....	....	72·9	13 7	759·4	16·13	....	
IV	0·3888	...	....	.. .	...	51·9	15·4	762·9	15·95	. ..	.
V	0·7048	.	. .	..	. ..	....	...	..	....	0·0259	3·67
VI	0·5362	...	....	...	..	....	.	....	....	0·0202	3·76

Percentage composition of ash-free substance.

					Average.
C	54·51	54·28	....	....	*54·39*
H	7·19	7·16	....	..	*7·17*
N	...	. .	16·75	16·56	*16·65*
O		....	...	....	*21·79*
					100·00

ANALYSIS OF PROTOELASTOSE (A1) FROM THE ALCOHOLIC FILTRATE.

No	Substance used. gram	H_2O found gram	H %	CO_2 found. gram	C %	N found c. c	N found T °C	N found Pressure. mm	N %	Ash found. gram	Ash %
I	0·4936	0·3113	7·00	0·9626	53·18	...	...	...	...		
II	0·4096	0·2592	7·03	0·8079	53·78	...		...	...		
III	0·4588	...	...	...		63·2	13·4	759·8	16·49	...	...
IV	0·4267	...	...	...	...	62·5	21·6	760·8	17·06		...
V	0·3655	...	...	...	...	...	...		...	0·0054	1·47
VI	0·5096	...	...	...	...	...	...		...	0·0075	1·47

Percentage composition of ash-free substance.

					Average
C	53·96	54·58			*54·27*
H	7·11	7·13			*7·12*
N			16·78	17·31	*17·02*
O					*21·59*
					100·00

The reactions of the two preparations were identical and were as follows; both were readily soluble in cold water, but only slightly soluble in hot water; in neutral solution, heat produced a turbidity which disappeared on cooling; the concentrated mineral acids gave precipitates soluble in excess; phosphotungstic acid, picric acid, tannic acid, 30 per cent. acetic acid saturated with salt, acetic acid and potassium ferrocyanide, and alcohol all produced precipitates; mercuric chloride and mercuric nitrate gave precipitates insoluble in excess; lead acetate and cupric sulphate both failed to give any precipitate; potassium mercuric iodide produced a precipitate in a hydrochloric acid solution; sodium carbonate and sodium hydroxide gave heavy precipitates and both the biuret and xanthoprotein test gave positive results. Further, the elastose is but slightly, if at all, diffusible. Long continued concentration of an aqueous solution leads to a separation of more or less of the substance as a gummy mass.

In composition, the protoelastose formed by action of the dilute acid and heat is almost identical with that of elastin itself.

Morochowetz,* in a recent paper on the laws of digestion, states that elastin by the action of heat and water passes into a new form,

* Loc. cit

elastose, which by further action passes into peptone. The elastose is described as a body completely soluble in water, not precipitable by mineral or acetic acids, but its solution is rendered turbid by heat. In its other reactions it resembles albumin. In composition, however, it differs decidedly from elastin and equally from our protoelastose. Morochowetz ascribes to it 55·9 per cent. carbon, 7·29 per cent. hydrogen, 16·68 per cent. nitrogen and 0·617 per cent. sulphur. As to the method employed in its preparation and purification we do not know, but as described it evidently is not akin to pure elastose.

Deuteroelastose.

In the salt-saturated filtrate from the first sodium chloride precipitate of protoelastose, there was present a substance precipitable as a gummy mass, by the addition of a little 30 per cent. acetic acid saturated with salt. Past experience with other proteoses has shown that, as a rule, all of the proto body is not precipitated by saturation of its neutral solution with salt, but that there usually remains a certain amount which on addition of salt-saturated acetic acid is precipitated, together with more or less of the deutero body, and that from this filtrate pure deutero can be separated by saturation with ammonium sulphate. In the present instance, however, it appeared that the acetic acid precipitate was of quite a different nature from the sodium chloride precipitate and that if it was not pure deuteroelastose, it at least contained only a trace of the proto body. Further, saturation of the acetic acid filtrate with ammonium sulphate gave only a slight precipitate, even when the mixture was heated, showing that if the salt-saturated acetic acid had not precipitated the deuteroelastose, little could have been formed.

The gummy precipitate separated by acetic acid and salt was purified somewhat by solution in water, and reprecipitation by saturation with salt and addition of a little salt-saturated acetic acid. It was then dissolved in water, made exactly neutral to test papers, and dialyzed until all chlorine was removed from the solution. The filtered fluid was then evaporated to dryness on a water-bath, and the powdered residue dried at 110° C. until of constant weight.

The composition of the substance is shown in the accompanying table, from which it is seen that the deutero body contains a noticeably smaller percentage of carbon than protoelastose, and a correspondingly higher content of oxygen. The difference between the sodium chloride precipitate and the acetic acid precipitate, however, becomes far more marked when the reactions of the two bodies are

compared. Deuteroelastose was readily soluble both in cold and hot water, and on heating a cold saturated solution only a slight turbidity was seen which, as in the proto reaction, disappeared when the solution cooled. This turbidity was no doubt due to the presence of a small amount of protoelastose, for later on we obtained a purer deutero body having nearly all of the reactions of the present preparation in which, however, the heat reaction was absent

ANALYSIS OF DEUTEROELASTOSE A 1

No	Substance used gram	H_2O found gram	H %	CO_2 found gram	C %	N found c.c.	T °C	Pressure mm	N %	Ash found gram	Ash %
I	0.5164			0.9894	52.24						
II	0.4003	0.2499	6.98	0.7708	52.51						
III	0.4648	0.2924	6.98	0.8885	52.12						
IV	0.4278	0.2704	7.02	0.8149	51.94						
V	0.8624					[illegible]9.8	13.8	759.8	16.48		
VI	0.4818					65.8	13.9	759.8	16.30		
VII	0.5870									0.0105	1.95
VIII	0.4371									0.0091	2.08

Percentage composition of ash-free substance

							Average
C	53.30	53.57	5[illegible]	52.99			*53.26*
H		7.07	[illegible] 13	7.13			*7.12*
N					16.76	16.64	*16.70*
O							*22.92*
							100.00

The deutero body, likewise, gave no precipitate whatever with the concentrated mineral acids, nor with acetic acid and potassium ferrocyanide. Alcohol gave no precipitate and salt-saturated 30 per cent acetic acid, when added to an aqueous solution of the substance, also gave no precipitate

Ferric chloride gave a slight turbidity, but no precipitate. With the other reactions of protoelastose, the deutero body showed close agreement Pure deuteroelastose, formed later on by the action of pepsin hydrochloric acid, gave no precipitate whatever with concentrated potassium hydroxide. This reaction, which is quite characteristic of protoelastose, was fairly distinct in the deutero body first described, which fact, coupled with the turbidity produced by heat, may be considered good evidence that the deuteroelastose was not perfectly pure.

Digestion of elastin by pepsin-hydrochloric acid.

An artificial gastric juice, free from both albumose and peptone, was prepared as follows; the cardiac portions from the mucous membranes of ten pigs' stomachs (820 grams) were placed in three litres of 0·4 per cent. hydrochloric acid and warmed at 40° C. for two weeks. The clear fluid filtered from the small residue of nuclein, antialbumid, etc., was then saturated with ammonium sulphate to precipitate the pepsin. This was filtered off, washed with saturated ammonium sulphate solution to remove any adherent peptone, dissolved in two litres of 0·2 per cent. hydrochloric acid and dialyzed until the sulphate was entirely removed. The resultant solution was mixed with an equal volume of 0·4 per cent. hydrochloric acid, making a pure and active pepsin-acid mixture.

In the first digestion of elastin, 150 grams of powdered elastin *A*, 1500 c.c. of the pepsin-acid mixture, and an equal volume of 0·4 per cent. hydrochloric acid, were warmed at 40° C. for 75 hours. At the end of this time the elastin was almost entirely dissolved. The acid fluid was filtered from the small residue remaining, and neutralized with potassium hydroxide, without giving any neutralization precipitate. The reactions of the fluid showed plainly the presence of elastoses similar to those formed by the action of acid. Saturation of the fluid with ammonium sulphate gave a heavy gummy precipitate, in the filtrate from which, nothing having the reactions of peptone could be discovered.

Protoelastose.

The ammonium sulphate precipitate was dissolved in water and the neutral fluid saturated with sodium chloride, by which a heavy gummy precipitate was formed, having all of the reactions described as characteristic of protoelastose. The product was purified by several reprecipitations with salt, then dialyzed and the solution evaporated to dryness on a water-bath, the residue powdered and dried at 110° C. until of constant weight.

The composition of the substance (protoelastose A 2) is shown in the accompanying table.

In reactions, the product agrees exactly with the protoelastose already described, being precipitated by the concentrated mineral acids, by acetic acid and potassium ferrocyanide, by 30 per cent. acetic acid and sodium chloride, by strong potassium and sodium hydroxide as well as by sodium carbonate. Its aqueous solution, likewise, shows the peculiar action towards heat, already described;

becoming turbid when heated, clear again as the solution cools. The product also gives the other reactions common to both proto- and deuteroelastose.

ANALYSIS OF PROTOELASTOSE. A 2.

No	Substance used gram	H_2O found gram	H %	CO_2 found gram	C %	N found c.c.	T °C	Pressure mm	N %	Ash found gram	Ash %
I	0·4607	0·2880	6·94	0·9103	53·88	....					
II	0·4952	0·3079	6·90	0·9768	53·76			..		..	
III	0·5546	..				76·2	18·9	759·4	16·41		
IV	0·3109				..	45·8	21·0	754·8	17·06		..
V	0·4608				..	....	..	..	..	0·0061	1·32
VI	0·5308				..	..		....	..	0·0078	1·37

Percentage composition of ash-free substance

					Average
C	54·58	54·46			*54·52*
H	7·03	6·99			*7·01*
N			16·64	17·29	*16·96*
O					*21·51*
					100·00

This body, which we prefer to call protoelastose, is apparently identical in composition and reactions with the *hemielastin* previously described by Horbaczewski,* and separated by him from a pepsin-acid digestion of elastin, by a method somewhat similar to the one employed by us

At first glance, it would appear from Horbaczewski's method of separation, that his hemielastin would consist of a mixture of proto- and deuteroelastose, instead of being identical with the proto body. But the fact that he *strongly acidified* his digestive mixture with acetic acid, prior to saturating it with salt, explains the matter. Deuteroelastose, which is precipitable from a salt-saturated solution by a little acetic acid, is more or less soluble when excess of the acid is added, and hence by acidifying the mixture sufficiently, the deutero might remain dissolved while the proto would be precipitated by salt from an acid solution, equally as well as from a neutral fluid.

* Ueber das Verhalten des Elastins bei der Pepsinverdauung Zeitschrift für physiologische Chemie, Band vi p 330

Deuteroelastose.

In the salt-saturated filtrates from protoelastose, deutero was separated as a gummy, sticky precipitate by addition of a little 30 per cent. salt-saturated acetic acid. It was purified by reprecipitation and dialysis, and the final neutral solution was evaporated to dryness and the residue dried at 110° C. until of constant weight. The amount was small and only the nitrogen was determined, 16·88 per cent.

In reactions, the body closely resembled the deutero already described; its aqueous solution giving no precipitate or turbidity whatever on the application of heat, no precipitate with alcohol, or with strong potassium hydroxide solution. It was likewise not precipitated by acetic acid and potassium ferrocyanide, by the concentrated or dilute mineral acids, nor by 30 per cent. acetic acid. In reactions, the body resembles the elastin peptone of Horbaczewski, like it being soluble in cold and warm water and dilute alcohol, and giving the same precipitations with phosphotungstic acid, picric acid, tannic acid, and with potassium mercuric iodide. It also gives the biuret and xanthoprotein reaction. It diffuses slowly.

With our present knowledge regarding peptones and proteoses, this body can hardly be considered as belonging to the former class, since it is precipitable both by ammonium sulphate, and by acetic acid when added to a salt-saturated solution; reactions not common to true peptones.

A second digestion of elastin *A* was made with the same quantities of pepsin-hydrochloric acid, and the same amount of powdered elastin, as in the first digestion. The products formed were separated in the same manner as the preceding, the elastoses being first precipitated collectively by saturation of the digestive fluid with ammonium sulphate.

On boiling the filtrate from this ammonium sulphate precipitate, a second gummy mass separated. This was collected on a cloth filter and washed with saturated ammonium sulphate solution. In the filtrate from this precipitate, no peptone could be detected. This second ammonium sulphate precipitate was purified by dialysis, etc., and the final solution evaporated to dryness and the substance dried at 110° C. Its composition is shown in the accompanying table, from which it is seen to be nearly identical with that of protoelastose. The reactions, however, indicate that it is a mixture of the two elastoses. Thus, while the concentrated mineral acids and potassium hydroxide give no precipitate, acetic acid and potassium ferrocyanide

produce a noticeable turbidity, as does also alcohol, and acetic acid and sodium chloride. Moreover, the aqueous solution becomes somewhat clouded on heating, clearing up again as the solution cools. Hence, the reactions would indicate a preponderance of deuteroelastose, while the composition points to an excess of the proto body.

ANALYSIS OF THE SECOND AMMONIUM SULPHATE PRECIPITATE.

No	Substance used gram	H_2O found gram	H %	CO_2 found gram.	C %	N found c. c.	N found T C	N found Pressure mm	N %	Ash found. gram	Ash %
I	0·4788	0·3115	7·23	0·9404	53·61		-		...	....	...
II	0·3781	0·2488	7·14	0·7405	53·40		-			....	..
III	0·4100	.....	..	....	. .	57·7	14·2	758 0	16·76	....	
IV	0·3968		.	.	.	57·6	22·6	758·9	16·72		.
V	0·4756	...				.	..	...	..	0·0048	1·00
VI	0·5016			.		.		...		0·0054	1·07

Percentage composition of ash-free substance.

					Average
C	54·14	53·93			*54·03*
H	7·30	7·22	.	.	*7·26*
N	.		16·92	16·89	*16·90*
O				.	*22·81*
					100·00

We must conclude, then, that this second gummy precipitate is simply a residue of the mixed elastoses not at first precipitated, perhaps from a lack of complete saturation with ammonium sulphate. Past experience, however, has shown that deuteroproteose is not as quickly or completely precipitated with ammonium sulphate as the other proteoses.

From the first ammonium sulphate precipitate, a large amount of protoelastose (A 3) was separated, having all of the reactions characteristic of this body, and the composition, when dried at 110° C., shown in the accompanying table.

A larger amount of deuteroelastose was separated from this digestion than in the preceding one, and after purification by the use of methods already described, a portion was dried at 110° C. for analysis. Its composition is shown in the accompanying table. Like the deuteroelastose formed by dilute hydrochloric acid, it contains a lower percentage of carbon than elastin or the proto body, while its content of nitrogen is higher than that of elastin. Its reactions were the same as the deutero previously obtained.

Deuteroelastose appears to be the same as the elastin peptone of Horbaczewski, as already mentioned; and the composition of the present product resembles it, in that it contains a similar percentage of carbon, but is unlike it in containing one per cent. more nitrogen.

ANALYSIS OF PROTOELASTOSE. A 3

No	Substance used gram	H_2O found. gram	H %	CO_2 found. gram	C %	N found c. c.	T. C.	Pressure mm.	N %	Ash found gram	Ash %
I	0·2990	0·1906	7·07	0·5841	53·27	-	-	-			-
II	0·4883	0·2750	6·97	0·8606	53 54	-	-	-			
III	0·3938	-				57·1	19·8	760 8	16·99		
IV	0·3238	-	-	---	----	47·1	21·6	757·2	16·89		
V	0·5562	-		--	- -		-	- --	-	0·0081	1 45
VI	0·4866	-		---		---		-	-	0·0079	1·62

Percentage composition of ash-free substance.

					Average
C	54·08	54·37		...	*54·27*
H	7·19	7·08			*7 13*
N	...		17·26	17 16	*17.21*
O	...				*21·39*
					100 00

ANALYSIS OF DEUTEROELASTOSE A 3

No.	Substance used gram	H_2O found. gram.	H %	CO_2 found gram.	C %	N found c. c.	T. °C	Pressure mm	N %	Ash found gram	Ash %
I	0·5067	0·3125	6·85	0·9681	52·10	-		- -	.		
II	0·6021	0·3752	6·92	1·1587	52·47	--	-	---		-	
III	0·4550	0·2705	6·60	0·8685	52·05	-		---	- --		
IV	0·6886	----	---	--		96·3	18·8	759·4	16 70		
V	0·3570	--	- -	- -		51·4	22·4	754·0	16·58		
VI	0·6688	-----	---	-----	- --	-	-			0 0201	3·02
VII	0·7748	-	--	-----	----				..	0 0247	2 91

Percentage composition of ash-free substance.

						Average
C	53·68	54·07	53·63	. ..	....	*53·79*
H	7·06	7·13	6·60	---	----	*6·99*
N	----	----	----	17·21	17·31	*17·26*
O	---	-	- -	----	----	*21·96*
						100·00

Horbaczewski's elastin peptone is described as not giving a precipitate with acetic acid and neutral salt. Deuteroelastose, likewise, gives no precipitate with acetic acid and salt, except when the solution is saturated or nearly saturated with the salt.

Another preparation of deuteroelastose was separated from a pepsin-hydrochloric acid digestion of elastin B. Its chemical composition is shown in the accompanying table, from which it is seen to differ somewhat from deutero A, but like it has a lower content of carbon than the proto body.

ANALYSIS OF DEUTEROELASTOSE *B.*

No	Substance used gram	H_2O found gram	H %	CO_2 found gram	C %	N found c.c.	N found T °C	N found Pressure mm.	N %	Ash found gram	Ash %
I	0·5919	0·3560	6·68	1·0934	50·37						
II	0·4201	0·2572	6·80	0·7796	50·60						
III	0·4852					64·9	14·0	756·8	15·91		
IV	0·4719					66·0	22·4	754·2	16·11		
V	0·7960									0·0398	5·00
VI	0·5882									0·0297	5·04

Percentage composition of ash-free substance.

					Average
C	53·01	53·21			*53·11*
H	7·03	7·14			*7·08*
N			16·81	16·90	*16·85*
O					*22·96*
					100·00

Digestion of elastin with pancreatic juice.

A strong solution of pure trypsin was prepared, according to Kühne's method,* from 100 grams of dried ox pancreas and added to 150 grams of powdered elastin B in 2 litres of 0·5 per cent. sodium carbonate. The mixture was warmed at 40° C. for four or five days, a little thymol being added to prevent putrefaction. At the end of this time, the elastin was nearly all dissolved and the filtered fluid on being tested gave the ordinary elastose reactions. On saturation of a portion of the neutralized fluid with ammonium sulphate, a heavy gummy precipitate was obtained, and in the filtrate no trace of peptone reaction could be found.

* Kühne and Chittenden, Zeitschrift für Biologie Band xix, p. 196.

The entire digestive fluid was therefore neutralized with dilute hydrochloric acid (no neutralization precipitate), and the protoelastose at once separated by saturation with sodium chloride. The product was purified by repeated precipitation with salt, and after dialysis, the resultant fluid was evaporated to dryness and the residue dried at 110° C. for analysis. The product contained considerable ash (7·4 per cent.), consisting mainly of calcium phosphate and sulphate, with some oxide of iron. Its composition, seen in the accompanying table, is somewhat different from the protoelastose formed by pepsin-hydrochloric acid, containing as it does a noticeably lower percentage of carbon. In its reactions, however, it resembles closely the preceding preparations It is readily soluble in cold water and the solution when heated gives the characteristic turbidity, which disappears as the solution cools. With acetic acid and potassium ferrocyanide, it gives the usual precipitate and also with the concentrated mineral acids, the latter dissolving in an excess of the acid. Unlike the protoelastose previously described, however, it gives with cupric sulphate a precipitate soluble in excess of the copper salt, and with sodium hydroxide no precipitate. In all other respects, its reactions resemble those of the proto body formed in pepsin digestion.

ANALYSIS OF THE SODIUM CHLORIDE PRECIPITATE—TRYPSIN DIGESTION OF *B*.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram	C %	N found c. c.	T °C.	Pressure mm.	N %	Ash found. gram.	Ash %
I	0·4455	0·2635	6·57	0·8045	49·24	....	....	.	...	...	
II	0·4650	0·2696	6·44	0·8860	49·03	...	..	.	..	...	
III	0·3765	....	..		.	49·7	16·0	765·4	15·77	..	
IV	0·6754	....	...		....	87·3	15·1	765·4	15·49	...	.
V	0·6478	....	....	.	....		...	..		0·0480	7·41
VI	0·8286	....	....	..	....	...	..	....	..	0·0610	7·36

Percentage composition of ash-free substance.

					Average
C	53·15	52·95			*53·05*
H	7·09	6·95			*7·02*
N			17·02	16·74	*16·88*
O					*23·05*
					100·00

In the salt-saturated filtrate from protoelastose, the addition of a little 30 per cent. acetic acid saturated with salt gave a second

gummy precipitate which was dissolved in water, the solution neutralized and dialyzed until all chlorine was removed. The solution, on evaporation, left a brownish residue, which was powdered and dried at 110° C. It was readily soluble in cold and hot water, its solution showing no turbidity whatever when heated. It likewise gave no precipitate with alcohol. Unlike the ordinary deutero-elastose, it did give noticeable precipitates with the mineral acids, soluble in excess, and also with acetic acid and potassium ferrocyanide. Lead acetate and cupric sulphate also gave precipitates, soluble in excess of the metallic salt. Sodium or potassium hydroxide failed to give any precipitate. In composition too, the product showed an approach to protoelastose formed by pepsin digestion, but unfortunately it contained over 5 per cent. of ash, and hence the quantitative results may perhaps be questionable.

ANALYSIS OF THE PRECIPITATE PRODUCED BY SALT-SATURATED ACETIC ACID—TRYPSIN DIGESTION OF *B*.

No	Substance used gram	H_2O found gram	H %	CO_2 found gram.	C %	N found c c	T °C.	Pressure mm.	N %	Ash found gram.	Ash %
I	0·4120	0·2466	6·65	0·7780	51·49	--	----	----	----	----	
II	0·3625	0·2185	6·69	0·6809	51·89	----	----	----	----	----	-
III	0·3121					45·6	14·7	756·5	15·81	---	---
IV	0·3136			-		45·8	19·4	754·8	15·52	----	---
V	0·6973						----	----		0·0370	5·30
VI	0·5663	---		-	-		----	..	.	0·0337	5·60

Percentage composition of ash-free substance.

					Average.
C	54·46	54·85			*54·65*
H	7·01	7·07			*7·04*
N			16·71	16·40	*16·55*
O					*21·76*

Of anything corresponding to heteroalbumose, we have found no trace. Further, under the conditions of our experiments, no appreciable amount of true peptone was formed in any of the digestions; at least, nothing approaching a peptone in reactions was to be found in any of the digestive fluids, after saturation with ammonium sulphate. We propose, later, to attempt a study of the elastin peptone,

TABLE SHOWING COMPOSITION OF THE VARIOUS PRODUCTS ANALYZED.

	Elastin A.	Elastin B.	Action of acid water at 100° C.			Action of pepsin-hydrochloric acid.					Pancreatic digestion of B.	
			Protoelastose A1.			Protoelastose.		Deuteroelastose.				
			Alcohol P. P.	Filtrate	Deutero. A1	A2	A3	A3.	B.	A3. Second $(NH_4)_2SO_4$ P P	NaCl Precipitate.	NaCl-CH_3COOH Precipitate.
C	54·24	54·08	54·39	54·27	53·26	54·52	54·27	53·79	53·11	54·03	53·05	54·65
H	7·27	7·20	7·17	7·12	7·12	7·01	7·13	6·99	7·08	7·26	7·02	7·04
N	16·70	16·85	16·65	17·02	16·70	16·96	17·21	17·26	16·85	16·90	16·88	16·55
S	..	0·30	....					...	...		....	..
O	21·79	21·57	21·79	21·59	22·92	21·51	21 39	21·96	22·96	21·81	23·05	21·76
Ash	0·90	0·31	3·71	1·47	2·01	1 34	1·53	2·96	5·02	1·03	7·38	5·45

using for this purpose the elastoses just described as well as elastin itself, and more vigorous digestive fluids, both peptic and tryptic.

In conclusion, then, we may say that elastin by the action of very dilute acid at 100° C., and by the proteolytic action of pepsin-hydrochloric acid, and of trypsin yields two primary cleavage products, which bear essentially the same relation to elastin that proto- and deuteroalbumose do to albumin. Further, that protoelastose is practically identical in reactions and composition with Horbaczewski's hemielastin.

The close relationship in composition of all the bodies analyzed is shown in the accompanying table. In considering these results, however, it is well to remember that the pancreatic preparations contain an over large amount of ash, and hence the figures may not be altogether trustworthy.

III.—The Influence of Urethan, Paraldehyde, Antipyrin, and Antifebrin on proteid metabolism. By R. H. Chittenden.

I. *The influence of urethan;*—from experiments made by *N. P. Washburn, Ph.B.*

Ethyl-urethan, $CO(NH_2)O.C_2H_5$, which has recently come into use as a hypnotic, is claimed by R. v. Jaksch* to be a sleep-producing agent, free from the usual disagreeable after effects common to most hypnotics. According to this observer, urethan does not appear to exert any poisonous action on the heart, nor to have any depressing influence on the arterial system. It is further assumed that the drug is without influence on digestion. Urethan acts mainly on the brain, the peripheral nervous system being unaffected, and according to v. Jaksch the hypnotic effect is always produced when the drug is taken in doses of 1 gram.

Smaller doses (0·25–0·5 gram) are uncertain in their action.

In view of the somewhat peculiar action of urethan as a hypnotic, we have undertaken to study the influence of the drug on the proteid metabolism of the healthy organism, in order to compare its action in this respect with that of other well known hypnotics.

Garnier,† alone, appears to have experimented in this direction. He states that, in the case of a man, a dose of 6 grams of urethan was followed by giddiness, etc., which condition, however, soon passed away. In this experiment, the excretion of urea was appreciably increased. In another experiment, the same observer found that a dose of 2 grams of urethan was also followed by an increased excretion of urea, in the case of a dog in a condition of hunger. A portion of the urethan was apparently converted into urea and excreted as such, but the greater part of the drug appeared in the urine unchanged. Garnier further states that large, nearly fatal doses, of the drug check

* Abstract in Jahresbericht für Thierchemie, 1885, p 70.

† Influence de l'urethane sur l'excretion des éléments azotes de l'urine. Compt. rend. soc. Biolog. 1886, p. 230.

metabolism, diminishing the quantity of urine excreted, as well as the amount of urea, uric acid, etc.

The experiments about to be described were conducted wholly upon the person of a healthy man of 66 kilos. body weight. A definite amount of food, of known composition, was taken daily and uniform habits of sleep, exercise, etc., were kept up during the whole time of the experiment, which extended over a period of six weeks. In this manner, body equilibrium was established and the daily excretions brought to a constancy of composition, as preliminary to studying the action of the drug. The daily diet was as follows:

312	grams	fresh beef, free from fat and tendons.
368	"	potatoes
227	"	wheat bread
149	"	boiled rice.
35	"	butter.
28	"	sugar.
6	"	salt
1200	"	water

The body-weight was ascertained each morning, and the 24 hours' urine collected and analyzed each day as follows: nitrogen was determined by the Kjeldahl method;* sulphur by fusing a given volume of the urine with pure potassium hydroxide and potassium nitrate in a silver crucible, and ultimately precipitating and weighing the sulphur as barium sulphate;† phosphorus by fusion of a portion of the urine in a like manner with potassium hydroxide and nitrate, precipitation of the phosphoric acid from a nitric acid solution by molybdic solution, solution of this precipitate in ammonia and reprecipitation with magnesia mixture, as ammonio-magnesium phosphate; chlorine by ignition with potassium nitrate, and titration of the prepared solution with a standard solution of silver nitrate.

On April 19th, analysis of the urine was commenced and continued for fourteen days before the first dose of urethan was administered. The drug was then taken for five consecutive days, a total of 73 grains or 4·73 grams, after which the urethan was discontinued for seven days. A second trial was then made by giving 89 grains

* Neue methode zur Bestimmung des Stickstoffs in organischen Körpern. Zeitschrift für Analytische Chemie, xxii, 366.

† For the details of the processes used, see Studies from Laboratory of Physiological Chemistry, Yale University, vol ii, p. 88

NORMAL URINE—WITHOUT URETHAN.

Date	Body weight.	Re-action.	Sp. Gr.	Total volume.	Nitro-gen.	Sul-phur.	Phos-phorus	Chlo-rine.	Amount of urethan taken.
April	grams			c. c.	grams	grams	grams	grams	
19	66400	acid	1027	950	17 484	1·210	1·128	5·000	0
20	66000	"	1026	1060	17 303	1·326	1·183	5·775	
21	66000	"	1028	930	16 707	1·278	1·166	4·952	
22	65800	"	1028	1010	16·891	1·160	1·141	6·191	
25	66200	"	1027	950	16 732	1·077	1·128	6·529	
26	66000	"	1023	1140	17 332	1·161	1·082	6·352	
27	65800	"	1023	1142	--	1·132	1·057	6.788	
28	65600	"	1022	1242	16 945	1·110	1·088	7·767	
29	65600	"	1023	1086	....	1·115	1·050	6·186	
30	...	"	1025	1132	---	1·264	1·195	7·850	
May									
1	65400	"	1028	1000	16·964	1·302	1·050	8·730	
2	65600	"	1026	900	17 392	1·217	1·010	5·795	
3	66000	"	1027	936	17 189	1·137	1·045	6 375	
4	65600	"	1026	1020	16·569	1·099	1·098	7·263	
Average			1025·8	1035	17 046	1 185	1·101	6·539	

UNDER THE INFLUENCE OF URETHAN.

Date.	Body Weight.	Re-action.	Sp. Gr.	Total volume.	Nitro-gen	Sul-phur	Phos-phorus	Chlo-rine.	Amount of urethan taken.
May	grams			c. c.	grams	grams	grams	grams	grains
5	65600	acid	1024	1188	16·161	1·163	1·184	8·459	5
6	65400	"	1018	1344	16·455	1·118	1·079	7·073	10
7	....	"	1019	1200	15·287	1·118	1·147	5·572	16
8	65200	"	1021	1165	15·568	1·184	1·473	7·068	20
9	65200	"	1029	900	16·384	1·201	1·197	6·241	22
10	65200	"	1028	930	17·704	1·214	1·056	5·528	0
11	64800	"	1028	980	17·644	1·404	1·138	6·371	
12	64600	"	1028	970	18·706	....	....	....	
13	64400	"	1021	1496	20·411	1·358	1·177	7·410	
14	....	"	1021	1254	16·258	1·306	1·146	5·512	
15	64400	"	1020	1336	18·836	1·264	1·073	7·776	
16	64200	"	1023	1182	18·680	1·272	1·090	6·367	
17	64200	"	1020	1412	18·485	1·419	1·130	8·130	20
18	63600	"	1016	1622	17·522	1·166	0·997	7·331	30
19	63200	"	1022	1130	16·597	1·265	0·977	7·707	39
20	63000	"	1026	1000	17·860	1·241	1·062	6·191	0
21	....	"	1026	950	18·397	1·269	1·093	5·558	
22	63600	"	1021	1300	21·690	1·431	1·170	7·405	
23	63600	"	1023	1116	20·192	1·442	1·156	5·873	
24	63400	"	1019	1424	20·340	1·332	1·150	7·142	

or 5·76 grams of urethan in three consecutive days, followed by a period of six days in which the drug was not taken.

The tables, giving the amounts in grams for the 24 hours' urine of the several elements determined, show plainly that urethan has a decided action on the metabolism of the body.

On examining the results in detail, it is to be seen that urethan has a very decided diuretic action, most noticeable on the second day the drug was taken. In fact, this may be called the initial action of the drug, since in both trials the amount of water excreted, after the first increase, rapidly diminished as the dose of urethan was increased, and indeed, the volume remained far below the average amount for two or three days after the drug had been discontinued, or until its elimination from the system was fairly complete, when the volume of fluid quickly rose to normal.

The excretion of nitrogen is at once affected by urethan, even a dose of five or ten grains bringing the nitrogen noticeably below the normal amount. In both series, the excretion of nitrogen was greatly diminished. On discontinuing the drug, the nitrogen excreted rapidly increased in amount, and on the third or fourth day after its discontinuance, the daily excretion of nitrogen passed considerably above the normal.

As regards the excretion of phosphorus, it would appear from the experiments that the administration of small doses of urethan gives rise to an increased excretion of this element, as seen from the results obtained on May 5–9th. With larger doses of the drug, however, the excretion of phosphorus is diminished, as seen from the results of May 17–19th. As the excretion of sulphur runs parallel with the excretion of nitrogen, both coming from the metabolism of proteid matter, it follows that urethan when taken in small quantities must exert an inhibitory influence on proteid metabolism, while it stimulates the decomposition of certain phosphorized matters. In larger doses, the inhibitory action of the drug on proteid metabolism is still more pronounced, while at the same time the excretion of phosphorus is also retarded.

In no case was any hypnotic action noticeable.

II. *The influence of Paraldehyde*;—from experiments made by *J. E. Dockendorff, Ph.B.*

In the following experiment, a full-blooded coach dog of 25 kilos. weight was employed. The animal was confined in a suitable cage, lined with galvanized iron and furnished with a bottom of wire netting, under which was a funnel-shaped tray, the whole so arranged as to allow all of the fluid excreta to pass into a collecting bottle underneath.

The animal was fed daily on a weighed diet consisting of dessicated beef, soda crackers and water. The beef was prepared by removing as thoroughly as possible all fat, fasciæ, tendons, etc., passing it through a sausage cutter and then drying it at a temperature below 60° C., until it had lost 75 per cent. of its weight. The dried and sampled beef was then preserved in tightly stoppered jars until needed. The crackers were ordinary soda crackers, containing about 0·7 per cent. of nitrogen. The daily rations consisted of 60 grams of crackers and 125 grams of the dessicated beef, soaked in 600 c. c. of water. This diet was commenced sometime before the urine was collected, and was continued throughout the experiment. Ultimately, the 24 hours' urine was analyzed each day, according to the methods described in the preceding experiment. Owing to irregularity of urination, and the difficulty of using a catheter, the quantity of urine obtained each day was necessarily quite variable, hence the composition of the normal urine was determined daily for three weeks, so that a sufficiently large number of results might be obtained to yield an accurate average for the normal period. Paraldehyde was then administered in gelatin capsules, about six hours after the dog had been fed, so that the drug might not interfere with digestion. Its administration was continued for eighteen days.

The results, expressed in grams for each 24 hours' urine, are shown in the accompanying tables.

NORMAL URINE. WITHOUT PARALDEHYDE.

Date.	Total Volume	Sp Gr.	Reaction	Nitrogen.	Sulphur.	Phosphorus.	Amount of Paraldehyde
April	c. c.			grams	grams	grams	
21	395	1036	acid.	12·540	0·883	0·862	0
22	840	1025	"	19·315	1·529	1·288	
23	660	1031	"	18 276	1·176	1·442	
24	490	1035	"	14·622	1·038	1·096	
25	610	1036	"	21·050	1·388	1·340	
26	410	1036	"	13·568	....		
27	550	1037	"	18 550	1·396	1·202	
28	415	1036	"	13 580	1·322	0·730	
29	420	1037	"	14·916	0·940	0·934	
30	630	1038	"	18·071	1·394	1·386	
May							
1	490	1040	"	18·415	1·172	1.214	
2	390	1038	"	12·896	0·826	0·806	
3	630	1038	"	23·425	1·499	1·410	
4	525	1036	"	17·244	1·285	1·098	
5	480	1035	"	13·849	1·188	0·862	
6	375	1035	"	11·672	0·810	0·784	
7	740	1032	"	23·191	1·648	1·538	
8	465	1031	"	13·682	1·085	0·898	
9	545	1032	"	16·239	1·340	1·166	
10	585	1032	"	15·756	1·119	1·134	
11	495	1032	"	14·406	1·145	0·904	
Av'age	526	1035	acid.	16·440	1·204	1·105	

WITH PARALDEHYDE $(C_2H_4O)_3$

Date	Total Volume	Sp. Gr	Reaction	Nitrogen.	Sulphur	Phosphorus.	Amount of Paraldehyde.
May	c. c.			grams	grams	grams	grams
12	540	1031	acid.	15·032	1·346	1·044	0·424
13	-	Urine	lost.				0·740
14	540	1028	acid.	13·624	1·000	0·776	0·715
15	310	1024	"	6·539	0·587	0·442	0·794
16	810	1027	"	20·191	1·593	1·339	0·755
17	460	1031	"	12·793	0·874	0·932	0·784
18	690	1033	"	21·091	1·444	1·296	0·702
19	525	1033	"	16·863	1·214	1·106	1·071
20	505	1032	"	14·523	1·016	0·978	1·536
21	785	1029	"	20·844	1·475	1·292	1·409
22	545	1031	"	16·756	1·122	0·462	1·811
23	555	1031	"	17·068	1·195	1·620	2·268
24	580	1032	"	18·202	1·245	1·080	2·675
25	360	1030	"	9·935	0·784	0·590	3·111
26	800	1033	"	25·695	1·924	1·476	3·632
27	460	1030	"	12·992	0·935	0·766	4·063
28	585	1033	"	19·174	1·368	0·990	4·958
29	695	1032	"	21·756	1·391	1·342	5·941
Av'age	570	1030	acid.	16·060	1·203	1·031	37·479

WITHOUT PARALDEHYDE.

Date.	Total Volume.	Sp. Gr.	Reaction.	Nitrogen.	Sulphur.	Phosphorus.	Amount of Paraldehyde.
May	c. c.			grams	grams	grams	
30	610	1028	acid.	17·672	1·309	0·992	0
31	570	1031	"	17·080	1·311	1·154	
June							
1	440	1028	"	12·201	0·765	0·780	
2	645	1031	"	19·550	1·376	1·299	
3	640	1030	"	17·798	1·237	1·608	
4	445	1026	"	11·112	0·979	....	"
Av'age	558	1029	acid.	15·902	1·163	1·166	

Throughout the experiment, the dog appeared perfectly well, and at no time showed any symptoms of nausea. Neither was there any special hypnotic action noticeable.

The average of the results shows plainly that the drug has little, if any, action on proteid metabolism. Under the influence of the paraldehyde there was a slight increase in the amount of water excreted. Bokai * has stated that the urinary secretion is slightly increased by paraldehyde. In our experiment, however, the diuretic action is not great. As regards the excretion of nitrogen, there is a slight diminution to be seen in the paraldehyde period. There is also a corresponding decrease in the excretion of phosphorus. The three periods, however, show such close agreement in results, it is obvious that, under the conditions of this experiment, paraldehyde has not exerted any special influence on proteid metabolism.

According to the experiments of Quinquad and A. Hénocque,† paraldehyde causes a diminution of body temperature, and at the same time a very noticeable falling off in the excretion of carbonic acid; thus, according to one of Quinquad's experiments, a dog after receiving by hypodermic injection 8 c. c. of paraldehyde gave off 5·5 grams of carbonic acid, while it expired during the same time, three-fourths of an hour after the injection, only 1·96 grams of carbonic acid.

* Ueber die physiologische Wirkung des Paraldehyds. Centralblatt für die medicinische Wissenschaften. 1887, p. 412.

† Abstract in Jahresbericht für Thierchemie. 1884, p. 374.

III. *Influence of Antipyrin* ;—from experiments made by *H. F. Adams, Ph.B.*

Previous experiments* with antipyrin, made in this laboratory, have shown that this drug, when introduced into the stomach of healthy rabbits, has little, if any, noticeable influence on the excretion of carbonic acid or on the body temperature, except in the case of toxic doses. Coppola,† likewise, found that the subcutaneous introduction of 0·1 to 0·3 gram of antipyrin in the case of dogs led to a reduction of body temperature of only 0·25 to 0·6 of a degree, while 0·3–0·4 gram of the drug was without any noticeable influence upon the excretion of urea. In fever patients, F. Müller,‡ however, had previously noticed a diminution in the excretion of nitrogen under the influence of antipyrin, while in the case of healthy men thé excretion was affected but very slightly, if at all. Jacubowitsch,§ likewise, had noticed in experiments on healthy and fevered children that the use of antipyrin led to a diminution both in the quantity and specific gravity of the urine, and also a diminution in the quantity of uric acid, phosphoric acid, sulphuric acid and of chlorides. L. Riess,‖ by carefully conducted experiments on nine typhus fever patients, found as a principal result that antipyrin in doses up to 12 grams per day diminished considerably the excretion of nitrogen, the diminution ranging in six series of experiments from 2·5 to 24·7 per cent. Umbach,¶ likewise, has studied the influence of antipyrin on the excretion of nitrogen, both on a dog and on himself, and he found that with a definite diet the excretion of nitrogen sank, under the influence of 4 grams of antipyrin, in two days about 2 grams, equal to 4 grams of urea. The uric acid excretion, however, was not materially affected.

In spite of these manifold experiments, we have deemed the matter of sufficient importance to warrant further study, especially with a view to the action of the drug on the metamorphism of nitrogenous matter in the *healthy* organism. The experiments were therefore tried upon a healthy man with a body weight of 77 kilograms, and

* Chittenden and Cummins. Studies, vol ii., p 231.

† Abstract in Jahresbericht fur Thierchemie 1885, p. 98.

‡ Abstract in Jahresbericht fur Thierchemie. 1884, p. 242

§ Abstract in Jahresbericht für Thierchemie. 1885, p. 444.

‖ Archiv fur experim. Pathol. u. Pharm. xxii, 127; also Abstract in Jahresbericht für Thierchemie. 1886, p. 417. Ueber stickstoffausscheidung bei antipyretischer Fieberbehandlung.

¶ Ueber den Einfluss der Antipyrins auf die stickstoffausscheidung. Abstract in Jahresbericht für Thierchemie. 1886, p. 418.

under definite conditions of diet, exercise, etc. Nitrogenous equilibrium was established prior to the experiment, and the following daily diet was strictly adhered to throughout the entire period.

386	grams	meat (beef).
340	"	potatoes.
227	"	wheat bread.
163	"	oat meal (steamed).
28	"	sugar.
42	"	butter.
120	"	milk.
1040	"	water.

In this experiment, nitrogenous metabolism was measured by determining the urea and uric acid contained in the daily excretion, instead of determining the total nitrogen. This was done in order to ascertain whether the drug has any special action on the excretion of uric acid. Urea was determined by Liebig's method, as modified by Pflüger.* Chlorine was previously determined by fusion with potassium nitrate and titration with silver nitrate in the usual manner, and then removed from the solution to be tested for urea, by a standard silver solution. Uric acid was determined by Salkowski's method, and phosphoric acid by titration with a standard uranium solution.

The accompanying tables give the results of the daily analyses. From these it is evident that under the conditions of this experiment, antipyrin has a decided inhibitory action on the proteid metabolism of the healthy human organism, as shown by the diminished excretion of urea and uric acid when the drug is taken. Antipyrin also tends to diminish the volume of the urinary secretion, this action being very marked in the second series, where comparatively large amounts of antipyrin were administered. As regards the excretion of phosphoric acid and of chlorine, nothing definite can be said. The more important changes produced by the antipyrin are shown in the following table of average daily results.

	Urea. grams	Uric acid. grain.	Total P_2O_5. grams.	Volume. c. c.	Sp. Gr.
Normal period............	41·806	0·586	3·185	951	1028
First antipyrin period....	38·875	0·556	3·026	848	1029
First after period.........	42·030	0·575	2·929	929	1028
Second antipyrin period..	40·854	0·472	2·941	822	1031
Second after period.......	44·220	0·537	2·923	957	1028

* Pflüger's Archiv für Physiologie, vol. xxi, p. 248.

Normal Urine.—Without Antipyrin.

Date.	Body weight.	Reaction.	Sp. Gr.	Total volume	Chlorine.	Total P_2O_5	P_2O_5 with Ca and Mg.	Uric acid.	Urea.	Amount of Antipyrin taken.
April.	grams			c. c.	grams	grams	gram	gram	grams	
24	77000	acid	1030	840	4·660	3·264	0·492	0·543	42·359	0
25	77200	"	1028	970	6·557	3·126	0·524	0·595	42·120	
26	77200	"	1027	950	3·820	3·236	0·499	0·570	41·427	
27	77200	"	1025	1085	5·407	3·043	0·509	...	41·026	
28	77000	"	1027	1040	6·113	3·341	0·541	0·702	42·768	
29	77000	"	1026	1090	5·781	2·957	0·561	0·651	41·616	
30	76900	"	1027	1000	6·006	3·284	0·601	0·636	41·492	
May										
1	76800	"	1029	970	6·756	3·166	0·586	0·560	41·861	
2	76800	"	1030	870	4·113	3·400	0·483	0·542	42·141	
3	76800	"	1030	860	4.117	3·238	0·495	0·571	41 913	
4	76600	"	1031	790	3·279	2·980	0·483	0·491	41·143	
Average			1028	951	5·146	3·185	0·525	0·586	41·806	

UNDER THE INFLUENCE OF ANTIPYRIN.

Date.	Body weight.	Reaction	Sp Gr.	Total volume.	Chlorine	Total P_2O_5.	P_2O_5 with Ca and Mg.	Uric acid	Urea	Amount of Antipyrin taken
May	grams			c. c	grams	grams	gram	gram	grams	grams
5	76600	acid	1031	800	3·016	3·288	0·599	0·501	40·995	30
6	76600	"	1031	780	3·688	3·118	0·596	0·548	38·391	30
7	76700	"	1027	1050	5·009	2 559	0 535	0·625	38·060	30
8	76800	"	1029	800	4 089	3·059	0·610	0·548	37 168	45
9	76600	"	1030	810	3 985	3·106	0·603	0·557	37·260	54
Average			1029	848	3·975	3·026	0·588	0·556	3 ·375	
10	76800	"	1024	900	4·658	2·652	0·550	0·607	39·744	0
11	76400	"	1026	890	3·867	2·541	0·567	0·602	42·895	
12	76400	"	1028	910	4 203	2·821	0·555	0·602	41·860	
13	75800	"	1028	1000	4 281	3·009	0·535	0·498	43·080	
14	75800	"	1028	915	3·625	3·265	0·589	0 582	42·510	
15	75800	"	1028	910	4·535	3·202	0 598	0·642	42·110	
16	75600	"	1028	980	4 759	3·011	0·514	0·495	42·012	
Average			1028	929	4·275	2·929	0 558	0·575	42·030	

UNDER THE INFLUENCE OF ANTIPYRIN—*Continued.*

Date	Body weight.	Reaction	Sp Gr	Total volume	Chlorine	Total P_2O_5	P_2O_5 with Ca and Mg	Uric acid	Urea	Amount of Antipyrin taken.
May	grams			c c	grams	grams	gram	gram	grams	grams
17	75400	acid	1030	880	4·442	3·286	0·542	0·534	41·694	40
18	75600	"	1030	880	4·048	3·335	0·627	0·564	42·404	50
19	75800	"	1032	790	4·341	3·052	0·635	0·406	41·143	60
20	74600	"	1032	760	4·273	2·748	0·588	0·385	39·227	60
21	.	"	1032	800	4·805	2·284	0·574	0·472	39·804	60
Average			1031	822	4·382	2·941	0·593	0·472	40·854	
22	75400	"	1030	910	4·477	2·652	0·590	0·621	44·076	0
23	74800	"	1028	990	3·795	2·632	0·500	0·516	45·114	
24	74800	"	1027	970	4·834	2·945	0·495	0·533	43·751	
25	74800	"	1027	965	3·576	3·196	0·532	0·514	45·490	
26	74600	"	1029	950	3·885	3·190	0·520	0·504	42·673	
Average			1028	957	4·113	2·923	0·527	0·537	44·220	

Since this work was finished we have seen an interesting paper by Dr. Kumagawa* on the action of certain antipyretics on proteid metabolism, in which is given the results of an experiment with antipyrin on the excretion of nitrogen and uric acid, in the case of a dog of 20 kilos. weight in a condition of nitrogenous equilibrium.

In this experiment, Dr. Kumagawa found that even large doses of antipyrin (51 grams in 16 days) produced no change whatever in the excretion of nitrogen (determined by the Kjeldahl method), but that there was a very noticeable increase in the excretion of uric acid (determined by Salkowski's method), amounting on an average to 65 per cent. above the normal excretion. These results stand in direct opposition to what we have found with somewhat smaller doses, in experimenting on the human organism. Whether the explanation of this difference is to be found in the different nature of the two organisms experimented with we cannot now say, but we hope at a later date to explain this apparently divergent action.

IV. *The influence of antifebrin*:—from experiments made by *H. C. Taylor, Ph.B.*

Antifebrin or acetanilide, which has recently come into use as an antipyretic, as a nervine and antiseptic, has been the subject of many clinical observations but has not as yet, so far as we know, been experimented with to ascertain its influence on proteid metabolism. We have endeavored, therefore, to ascertain the influence of this new antipyretic on the nutrition of the healthy human organism, believing that such results may possibly be of greater value than those obtained by experimenting on animals. At the same time it is to be borne in mind, that an antipyretic especially may produce an effect upon the healthy organism quite different from that which the same doses would produce on an organism rendered perhaps more susceptible by disease, as in fever. The experiment was therefore conducted upon the person of a young man of 64 kilos. body weight, brought into a condition of nitrogenous equilibrium and maintained throughout the experiment upon a weighed diet of known composition. For reasons already given, the excretion of nitrogenous matter was measured by determining in the 24 hours' urine the amount of urea and uric acid, using the methods employed in one of the preceding experiments. Sulphur, phosphorus and chlorine were also

*Ueber die Wirkung einiger antipyretischer Mittel auf den Eiweissumsatz im Organismus. Virchow's Archiv, Band cxiii, p. 192.

determined each day by methods already indicated. After nitrogenous equilibrium had been established, and the urine analyzed for ten consecutive days, antifebrin was administered daily in divided doses, at a time not to interfere with digestion, for a period of nine days. The daily dose was gradually increased until at last there was a slight approach to cyanosis. In all, 13·3 grams or 205 grains of the antipyretic were taken. No disagreeable symptoms were experienced, but there was a very noticeable lividity of countenance with a decided blueness of the lips, and a slight darkening of the skin near the cheek bones.

The initial daily dose was 0·4 of a gram or a little over 6 grains, and was rapidly increased to 2·6 grams or 40 grains per day, given in three doses. There are, to be sure, many cases recorded where apparently smaller doses have led to serious results, but careful watching failed to show any symptoms whatever even suggestive of any disagreeable action on the digestive system, the circulation or respiration. Weinstein, indeed, has said that persons not suffering from fever may take antifebrin for weeks together without any effect on the circulation, while according to Herczel the long-continued administration of antifebrin, thirty to forty-five grains daily for six weeks, may lead to what he terms aniline anaemia with solution and decomposition of the hæmoglobin of the blood. In fact, the latter observer considers that aniline is set free from the acetanilide and that the decomposition of the blood-coloring matter is due to this cause. Whether this is the cause of the cyanosis so often spoken of in connection with this drug is uncertain.

In the second antifebrin period, 13·9 grams or 214 grains of the drug were taken in seven days, accompanied at the close with the same approach to cyanosis as before.

Examination of the analytical results shows plainly that under the conditions of this experiment the excretion of urea is not very greatly affected. There is, however, in both antifebrin periods a slight increase, indicating increased proteid metabolism under the influence of the drug. This increased excretion of urea is more apparent in the individual results than in the average of the series. Thus, in the normal urine it is to be noticed that the daily excretion of urea never exceeded 34·5 grams, while in the first antifebrin period, on the days when the largest doses of acetanilide were taken, the excretion of urea amounted to 35–37 grams, and in the after period quickly fell to about 33 grams per day. The same peculiarity is also noticeable, to a less extent, in the second antifebrin period.

NORMAL URINE—WITHOUT ANTIFEBRIN.

Date	Body weight.	Reaction.	Sp. Gr.	Total volume	Urea.	Uric acid.	Sulphur.	Phosphorus	Chlorine	Amount of Antifebrin.
April	grams			c. c.	grams	gram	grams	grams	grams	
23	64200	acid	1025	790	33·331	-	1·380	0·966	2·967	0
24	64200	‥	1016	1280	33·280	0·749	1 154	0 864	4·404	
25	64060	‥	1017	1260	33 486	0·708	1·207	1·227	3·603	
26	64000	‥	1014	1340	33·947	0 739	1·254	0 859	3·520	
27	64000	‥	1018	1030	33·058	0·753	1·220	1·041	3·221	
28	64000	‥	1017	1150	34·502	0·779	1·296	0·881	4·027	
29	63800	‥	1015	1250	32 619	0·723	1·222	0·862	4·377	
30	64200	‥	1023	880	33·440	0·741	1·289	0.842	4·073	
May										
* 1	64000	‥	1013	1590	34·370	0·694	1·350	0·821	6·366	
2	64000	‥	1016	1250	33·334	0 777	1·124	1·122	4·078	
Average			1017	1176	33·536	0 740	1·249	0·948	4·063	

FIRST ANTIFEBRIN PERIOD

Date.	Body weight.	Reaction	Sp. Gr.	Total volume	Urea	Uric acid	Sulphur	Phosphorus.	Chlorine.	Amount of Antifebrin.
May	grams			c. c.	grams	grams	grams	grams	grams	grams
3	64000	acid	1015	1400	33·190	0·671	1·241	0·932	4·743	0·4
4	64000	"	1013	1630	34·155	0·762	1·313	0·910	5·505	0·7
5	64000	"	1017	1190	29·920	0·611	1 096	0·510	4·912	0·9
6	64000	"	1014	1770	35·063	0·670	1·380	1 167	6 533	1 2
7	64000	"	1018	1190	29·843	0·538	1·241	0·992	4·153	1·5
8	64000	"	1017	1300	33·882	0·651	1·353	1·012	0·520	2·4
9	63800	"	1017	1230	35·172	0·572	1·294	0·948	4·886	2·6
10	63800	"	1017	1280	35 996	0·639	1 299	0·846	3·843	2·6
11	63800	"	1015	1470	37·011	0·596	1·318	1·102	4·782	1·0
Average			1016	1384	33.804	0·634	1·282	0·935	4·375	

FIRST PERIOD AFTER ANTIFEBRIN.

Date.	Body weight.	Reaction.	Sp. Gr.	Total volume.	Urea.	Uric acid	Sulphur	Phosphorus.	Chlorine	Amount of Antifebrin.
May	grams			c. c.	grams	grams	grams	grams	grams	
12	63800	acid	1017	1210	32·965	0·690	1·372	0·858	4·314	0
13	63800	"	1018	1800	33·596	0·705	1·374	0·982	5·405	
14	63600	"	1016	1400	33·596	0·650	1·412	0·965	4·292	
15	63600	"	1015	1560	36·245	0·715	1·214	1·099	4·465	
16	63600	"	1013	1880	34 799	0·785	1 489	1·089	5·380	
17	63400	"	1016	1370	33·437	0·755	1·443	0·883	4·484	
18	63400	"	1016	1400	33·904	0 755	1·356	0·878	5·904	
19	63500	"	1013	1710	32·736	0·640	1·588	0 969	5·472	
20	63600	"	1016	1500	32·377	0·645	1 376	0·980	6 043	
Average			1015	1531	33 739	0·704	1·404	0·967	5·084	

SECOND ANTIFEBRIN PERIOD.

Date.	Body weight.	Reaction	Sp Gr.	Total volume	Urea	Uric acid	Sulphur.	Phosphorus	Chlorine.	Amount of Antifebrin.
May	grams			c. c.	grams	grams	grams	grams	grams	grams
21	63800	acid	1017	1280	34·027	0·437	1·360	0·959	5·814	1·0
22	63800	"	1016	1340	33·673	0·460	1·312	0·841	5·314	2·0
23	63800	"	1019	1270	33·882	0·592	1·272	0·860	5·995	2·2
24	63900	"	1018	1340	33·968	0·570	1·235	0·876	7·001	2·5
25	63800	"	1018	1420	34·579	0·595	1·432	0·874	8·302	2·5
26	63800	"	1022	1220	32·990	0·626	1·249	0·996	6·295	2·5
27	63600	"	1018	1510	34·765	0·721	1·399	0·864	7·510	1·2
Average			1018	1340	33·983	0·571	1·323	0·896	6·604	
28	63600	"	1014	1800	33·792	0·596	1·492	1·017	8·158	0
29	63600	"	1022	1000	33·201	0·639	1·375	0·785	5·917	
30	63600	"	1025	920	32·880	0·681	....	0·876	5·279	
Average			1020	1240	33·291	0·639	1·423	0·892	6·451	

We must conclude, therefore, that acetanilide tends to increase somewhat the excretion of urea, but that with such doses as we have employed the increase in proteid metabolism cannot be great. This is further indicated by the lack of any corresponding change in the excretion of sulphur.

The excretion of phosphorus is also unaffected by antifebrin.

On the excretion of uric acid, however, our results indicate a special inhibitory influence. This is quite apparent both in the averages of the different series and in the individual results, and, if correct, would appear to be the most marked characteristic of antifebrin, so far as its influence on proteid metabolism is concerned. Various observers have stated that antifebrin acts as a diuretic, others that it decreases the secretion of water, and while doubtless both results have been seen to follow its administration in diseased conditions of the system, our experiment on a healthy man gives no evidence of any action of this kind.

Since the foregoing was written we have seen the results of Kumagawa's* experiment with antifebrin on a dog, from which he concludes that acetanilide taken in small doses (2–3 grams per day) does not give rise to any appreciable increase in the decomposition of proteid matter, but that larger doses (4–5 grams per day) cause a very marked increase, as indicated by the increased excretion of nitrogen. Such doses are, however, as Kumagawa himself admits, too large, especially when given to a moderate sized dog, to have the results of any practical value. Lépine,† too, experimenting on a hungry dog, thought he found an increase in the excretion of nitrogen after giving two doses of one and two grams of antifebrin. Further, Ademski‡ is quoted as considering that urea is increased, but the total quantity of nitrogen decreased by antifebrin. Bokai, that the amount of nitrogen is diminished and Berezooski that the urea decreases with the fall of temperature. Whether these latter views are founded on actual experiments or are mere conjecture I do not know.

According to Jaffe and Hilbert,§ rabbits fed upon antifebrin excrete it mainly as paramidophenol-sulphuric acid, and Kumagawa has likewise found, in the case of a dog, that neither acetanilide nor aniline appear in the urine, but that the antifebrin is excreted mainly as paramidophenol united to sulphuric acid.

* Virchow's Archiv. Band cxlii, p. 171.

† See Salkowski's Bemerkung in Virchow's Archiv, Band cxiii, p. 394.

‡ See Report on Antifebrin in the Therapeutic Gazette, vol. xii, p. 571.

§ Zeitschrift für physiologische chemie, xii, p. 307.

IV.—The influence of several new therapeutic agents on amylolytic and proteolytic action. By R. H. Chittenden and C. W. Stewart, Ph.B.

In view of the pronounced action of a number of newly discovered therapeutic agents on metabolism, we have deemed it of importance to widen our knowledge regarding their physiological action by attempting a study of their behavior towards the amylolytic and proteolytic ferments, with the hope of gaining some insight into their influence on normal digestion

The methods employed were similar to those used in previous experiments of this kind,* in which the action of varying percentages of the drug were determined quantitatively.

Influence on amylolytic action.

As amylolytic ferment, human mixed saliva was employed, filtered and carefully neutralized, and then diluted with distilled water in the proportion of 1 to 5. The experiments were made in series, in which one digestion of each series served as a control for comparison. The volume of each digestive mixture was 100 c. c., in which was present 1 gram of perfectly neutral potato starch previously boiled with a portion of the water, 10 c. c. of diluted neutral saliva and a given quantity of the substance to be experimented with. The mixtures were warmed at 40° C. for thirty minutes, after which further action of the ferment was stopped by heating the solution to boiling. The extent of amylolytic action was then ascertained, by determining in one-fourth of the solution the amount of reducing substances by Allihn's gravimetric method.† For the sake of convenience, the total amount of reducing substance was calculated as dextrose, from which in turn was calculated the percentage of starch converted.

Antipyrin.

With this new antipyretic, several series of experiments with small percentages were made which show clearly that the substance is

* Studies from the Laboratory of Physiological Chemistry, Yale University, vols. i and ii.

† Zeitschrift für analytische chemie, xxii, p. 448.

without any appreciable influence. When present in larger percentages, the drug was found to have a slight inhibitory influence on amylolytic action, as the following series of experiments show:

Per cent of Antipyrin	Total amount of reducing substances	Starch converted	Relative amylolytic action
0	0·3446 gram	31 01 per cent	100·0
0 5	0·3446	31 01	100 0
1 0	0·3424	30·82	99 4
3·0	0 3278	29 50	95·1
5 0	0 3112	28 01	93 6

Coppola,* in studying the physiological action of antipyrin, found that three per cent. of the substance did not hinder the inversion of cane sugar by yeast, but did prevent alcoholic fermentation. Further, that the same percentage hindered slightly the action of malt diastase on starch, and had a decided inhibitory influence on the alkaline fermentation of urine.

Antifebrin.

Owing to the comparative insolubility of antifebrin or acetanilide in water, large percentages could not be employed. Such as were used, however, clearly show that this antipyretic has little influence on amylolytic action.

Per cent of Antifebrin	Total amount of reducing substances	Starch converted	Relative amylolytic action
0	0 3604 gram	32 44 per cent.	100 0
0 10	0·3600	32 40	99 9
0 25	0·3638	32 70	100 8
0·50	0·3550	32 00	98·6
0	0 3382	30 44	100 0
2·0	0 3298	29 68	97 5

In this connection, it is interesting to notice that Kumagawa* has found antifebrin to have a strong antiseptic action on the putrefactive processes of the intestinal canal, and Van Seer has observed that milk does not undergo fermentation if saturated with it, and also that it will prevent albumin becoming putrid †

Urethan.

With ethyl-urethan, two series of experiments were tried, with the following results:

* Jahresbericht für Thierchemie. 1885, p. 98

† Virchow's Archiv, Band cxiii, p. 181.

‡ See The Therapeutic Gazette, vol. xii, p. 566.

Per cent of Urethan	Total amount of reducing substances	Starch converted	Relative amylolytic action.
0	0 3382 gram	30·44 per cent	100·0
0·5	0 3550	31 95	104·6
0	0·3402	30 62	100·0
2 0	0·3446	31 01	101 3
3 0	0 3352	30 17	98·5
5·0	0 3268	29 40	96·0

Here, there is noticeable, with the smaller percentages, a slight stimulation of amylolytic action, but it is not sufficiently large to be very marked.

Paraldehyde.

This substance shows very strong inhibitory action, even 0·5 per cent. diminishing the amount of starch converted by 30 per cent. It must be remembered, however, that the aldehyde is only slightly soluble in water, and that it is more or less volatile. The experiments were conducted in small flasks and the aldehyde kept more or less emulsionized with the aqueous solution by shaking the mixtures, but obviously the percentages given can only approximately represent the amount actually taking part in the reaction.

Following are the results of two series of experiments:

Per cent of Paraldehyde.	Total amount of reducing substances	Starch converted	Relative amylolytic action
0	0 3554 gram	31 98 per cent	100·0
0 1	0 3534	31 81	99·5
0 2	0 3528	31 75	99·3
0 5	0 2468	22 21	69 5
1 0	0 1066	9 59	30·0
0	0 3554	31 98	100 0
0 8	0·1392	12 52	39·1
1 0	0 0948	8 53	26·6
1 5	0 0620	5 58	14·3
2·0	0 0446	4·01	12·5

Thallin Sulphate.

This salt has a more marked influence on the amylolytic action of saliva than any of the preceding substances. Very small percentages have a noticeable stimulating action, while the presence of 0·2 per cent. of the salt almost entirely stops the action of the ferment. The results of the following two series show one or two small points of difference, but in the main they point to the same general action.

Per cent. of Thallin Sulphate.	Total amount of reducing substances.	Starch converted.	Relative amylolytic action.
0	0·2534 gram.	31·81 per cent.	100·0
0·025	0·3648	32·83	103 2
0·050	0·3810	34·36	108·0
0·100	0·3540	31·86	100·1
0·200	0·0690	6·21	19 5
0·300	trace.		
0	0·3652	32·86	100·0
0·025	0·3798	34·18	104·0
0·050	0·3872	34 89	106 1
0·080	0·3812	34·81	105·9
0·10	0·3148	28·33	86·2

Caffein and Thein.

These two closely related alkaloids were found to have only a slight action on the amylolytic ferment, producing when present in considerable amount a slight diminution in the amount of starch converted. With two per cent. of the alkaloids, the following results were obtained :

Per cent. of alkaloid.	Total amount of reducing substances.	Starch converted.	Relative amylolytic action
0	0·3620 gram.	32·57 per cent.	100 0
2·0 Caffein.	0·3342	30·08	92·4
0	0·3664	32·97	100·0
0·2 Thein.	0·3440	30·96	93·9

Influence on proteolytic action.

The influence of the above therapeutic agents on the proteolytic action of pepsin-hydrochloric acid was determined, as in preceding work of this kind,* by ascertaining the amount of fibrin digested or dissolved in a given time, by a definite volume of standard, artificial gastric juice, in the presence of varying amounts of the substances to be tested. The gastric juice was made by dissolving 10 c. c. of a glycerin extract of pepsin in one litre of 0·2 per cent. hydrochloric acid. The volume of each digestive mixture was 50 c. c., composed of 25 c. c. of the above mentioned artificial gastric juice, and 25 c. c. of 0·2 per cent. hydrochloric acid containing the desired amounts of the substances to be tested. The proteïd material consisted of purified fibrin, coarsely powdered and dried at 110° C. One gram of fibrin was used in each experiment. The digestive mixtures were warmed at 40° C. for a certain length of time, usually two hours,

* Studies from the Laboratory of Physiological Chemistry of Yale University, vols.

after which further proteolytic action was stopped by heating the mixtures to boiling. The undissolved residues were then collected on dried, weighed filters, washed thoroughly with boiling water, and finally dried at 110° C. until of constant weight. The amount of fibrin dissolved is taken as a measure of proteolytic action.

Following are the results obtained with the various substances tested:

Antipyrin.

Per cent. of Antipyrin.	Undigested residue.	Fibrin digested.	Relative proteolytic action.
0	0·507 gram.	49·3 per cent.	100·0
0·2	0·522	47·8	96·9
0·5	0·573	42·7	86·6
1·0	0·688	31·2	63·3
	Longer time at 40° C.		
0	0·143	85·7	100·0
0·5	0·213	78·7	91·8
3·0	0·964	3·6	4·2
5·0	1·008	0	0

Antifebrin.

Per cent. of Antifebrin.	Undigested residue.	Fibrin digested.	Relative proteolytic action
0	0·129 gram.	87·1 per cent.	100·0
0·1	0·145	85·5	98·1
0·2	0·166	83·4	95·8
0·5	0·212	78·8	90·5
1·5	0·371	62·9	72·2

Urethan.

Per cent. of Urethan.	Undigested residue.	Fibrin digested.	Relative proteolytic action.
0	0·148 gram.	85·2 per cent.	100·0
0 2	0·138	86·2	101·2
1·0	0·171	82·9	97·2
3·0	0·224	77·6	90·9
5·0	0·240	76·0	89·4

Paraldehyde.

Per cent. of Paraldehyde.	Undigested residue.	Fibrin digested.	Relative proteolytic action.
0	0·263 gram.	73·7 per cent.	100·0
0·05	0·219	78·1	105·9
0·10	0·246	75·4	102·3
0·30	0·255	74·5	101·1
1·00	0·264	73·6	99·9
2·00	0·269	73·1	99·2

Thallin sulphate.

Per cent. of Thallin sulphate.	Undigested residue.	Fibrin digested.	Relative proteolytic action.
0	0·379 gram.	62·1 per cent.	100·0
0·05	0·243	75·7	121·9
0·10	0·327	67·3	108·4
0·30	0·395	60·5	97·4

Thein and Caffein.

Per cent. of alkaloid	Undigested residue.	Fibrin digested.	Relative proteolytic action
0	0·105 gram.	89·5 per cent.	100·0
1·0 Thein.	0·252	74·8	84·7
4·0 "	0·179	82·1	91·8
4·0 Caffein.	0·584	41·6	46·5

These results show that antipyrin has a decided inhibitory influence on the action of the proteolytic ferment, and that when present to the extent of 3·0 per cent. it practically stops all digestive action. Antifebrin has also an inhibitory action, perhaps equal to that of antipyrin, but owing to its greater insolubility in acid fluids large percentages of the substance could not be tested.

Urethan has only a slight retarding action, even when present to the extent of 5 per cent.

Paraldehyde and thallin sulphate both show a very decided stimulating action when small fractions of one per cent. are present, the latter, particularly, causing a much larger amount of fibrin to be digested than in the control experiment.

Thein and caffein both show an inhibitory influence on the ferment, that of caffein being much greater than that of thein.

On the proteolytic action of trypsin in an alkaline solution, two substances only were tested, antifebrin and paraldehyde. The experiments were conducted in the same manner as with pepsin-hydrochloric acid, except that a solution of trypsin in 0·3 per cent. sodium carbonate was employed in place of the pepsin-acid, and the mixture warmed for a longer time at 40° C. Following are the results obtained, showing a much more pronounced inhibitory action on this ferment than on pepsin.

Per cent. of substance.	Undigested residue.	Fibrin digested.	Relative proteolytic action.
0	0·159 gram.	84·1 per cent.	100·0
0·2 antifebrin.	0·368	63·2	75·1
1·0	0·741	25·9	30·8
0·2 paraldehyde.	0·368	63·2	75·1
2·0	0·959	4·1	4·9

V.—Caseoses, Casein Dyspeptone, and Casein Peptone. By R. H. Chittenden.

In a previous paper on "Casein and its Primary Cleavage Products,"* the writer expressed the intention of continuing the study of the caseoses formed in pepsin digestion, and also of studying pure casein peptone and the so-called casein dyspeptone In the fulfillment of this intention, experiments upon these subjects have been carried on in this laboratory during the past two years, with the aid of several co-workers, and the results are here presented collectively.

I.- *Casein Dyspeptone*;—from experiments by *L. A. Conner, Ph.B.*, and *C. A. Tuttle, Ph B*

When casein is exposed to the action of pepsin-hydrochloric acid at 40° C., or even at ordinary temperatures, it is decomposed, as is well known, into soluble caseoses and peptone. In every such digestion, however, there always remains a certain amount of an insoluble pasty, grayish white substance, which apparently is not susceptible to the further action of gastric juice, no matter how long continued. This insoluble substance, which is noticeable to a greater or less extent in the pepsin digestion of all proteids, but particularly so with casein, and which received from Meissner the name of dyspeptone, was examined somewhat carefully by Lubavin in 1870,† who described some of its properties. He considered this casein dyspeptone as a mixture of two distinct bodies, separable from each other by the action of sodium carbonate. Substance *A*, that portion of the dyspeptone soluble in sodium carbonate, was described by Lubavin as a body containing 4·6 per cent. of phosphorus, 13·3 per cent. of nitrogen, 48·5 per cent. of carbon and no sulphur, corresponding to the formula $C_{21}H_{47}N_6PO_{11}$. Substance *B*, insoluble in sodium carbonate, was slowly soluble in sodium hydroxide, contained sulphur, but only a small trace of phosphorus and evidently contained more or less

* Chittenden and Painter. Studies from Laboratory of Physiological Chemistry Yale University, vol. ii., p. 156.

† Hoppe-Seyler. Med. Chem. Untersuchungen, p. 463.

admixture of fat. Judging from the description, substance *A* must have been an acid compound of the body studied, mixed with more or less undigested casein; while substance *B* was doubtless a mixture of fat and the body *A*. However this may be, our results show conclusively that no body having the formula ascribed by Lubavin to his substance *A*, can be separated from the undigestible residue of casein in pepsin-hydrochloric acid.

In all of the experiments to be described, the casein employed was freshly prepared from skim milk by precipitating the greatly diluted fluid with dilute acetic acid, washing thoroughly with water, redissolving the precipitate in water containing a trace of ammonia and reprecipitating, repeating this operation three or four times.

In subjecting casein to the action of artificial gastric juice the conditions were varied more or less in the individual experiments, so that if the so-called dyspeptone be a mixture of two or more substances, the varying conditions under which the digestions were made might so change the nature of the mixture, that on analysis, it would become apparent.

Digestion A.

The casein from five gallons of milk was placed in four litres of 0·4 per cent. hydrochloric acid and warmed to 40° C. To this was added 200 c. c. of a dialyzed pepsin solution, prepared from a glycerin extract of the ferment, and the mixture kept at 40–45° C. for forty-eight hours. At the end of this time there was still a comparatively large mass of gelatinous matter undissolved, composed in part, no doubt, of swollen casein. The entire mixture was then diluted considerably with water and treated with dilute alkali to near neutralization, leaving the fluid, however, distinctly acid. The undigested matter was then filtered off and washed thoroughly with water. This partial neutralization of the digestive mixture was found necessary, owing to the extreme slowness with which the acid fluid filtered. The undigested matter was again warmed at 40° C. for forty-eight hours, with four litres of a much more vigorous pepsin mixture containing 0·4 per cent. hydrochloric acid. The residue still undissolved was filtered off and washed with water. The acid filtrate gave no precipitate whatever on neutralization. A third time the undigested matter was warmed at 40° C. for sixty hours, with four litres of a still stronger artificial gastric juice. The quantity of insoluble matter did not appear to be diminished at all by this third treatment with pepsin and acid. The substance was thereupon filtered from the acid

fluid, and washed with water until the washings gave no reaction for chlorides. It was then treated in the cold with one litre of one per cent. sodium carbonate, in which it appeared to dissolve completely. On filtration there appeared a small whitish residue, which on treatment with ether, dissolved in great part, thus showing its fatty nature. There remained, however, a very small residue of a heavy, brownish substance too small in quantity to be considered other than as an impurity. On adding dilute hydrochloric acid to the alkaline fluid, no precipitate was obtained until the fluid was made distinctly acid, when the dyspeptone was thrown down as a heavy flocculent precipitate. In the filtrate, the biuret and Millon's test showed only a faint trace of an albuminous body. The precipitate of dyspeptone was washed with water until the washings gave no reaction with silver nitrate, after which it was dissolved in one per cent. sodium carbonate, the fluid made exactly neutral with dilute hydrochloric acid, thymolized, and then dialyzed in running water until all chloride was removed from the fluid.

The neutral fluid of dyspeptone so obtained, was concentrated to a thick syrup on the water-bath, and then while still warm, it was treated with 95 per cent. alcohol and a little absolute alcohol. A moderately heavy precipitate of dyspeptone resulted, but apparently not all of the substance was precipitated. On standing for forty-eight hours, the fluid was found in a thick, gelatinous condition. The coagulum was insoluble in 95 per cent. alcohol, but readily and completely soluble in water. It was therefore washed thoroughly with alcohol, allowed to stand under absolute alcohol for several days, then treated with cold ether, after which it was dried, powdered and placed in a fat extractor and extracted with boiling ether as long as any fatty matter was dissolved, a process which took several days. About nine grams of the pure, dry substance were obtained.

A portion was then dried at 110° C. until of constant weight, for analysis. Its composition is shown in the accompanying table. The methods of analysis employed were the same as those previously described. Phosphorus was determined by fusing the substance in a silver crucible with potassium hydroxide and potassium nitrate, acidifying the mixture with nitric acid, evaporating to dryness, dissolving the residue in water acidified with nitric acid and precipitation of the phosphoric acid, first with molybdic solution, and lastly with magnesia mixture and final weighing of the phosphorus as magnesium pyrophosphate.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	T. °C.	Pressure mm.	N %	Ash found. gram	Ash %	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	$Mg_2P_2O_7$ from the Ash gram.	P of Ash. %	$Mg_2P_2O_7$ after fusion with $KOH + KNO_3$. gram.	P %	P after deducting P of Ash. %
I	0·2389	0·1325	6·04	0·3872	44·20	...	...	...	...	...	...	...	...	...	...	...	...	...
II	0·3058	0·1695	6·16	0·4949	44·13	...	...	...	...	...	...	...	...	...	...	...	...	...
III	0.4003	...	...	...	...	44·9	19·4	754·4	13·05	...	...	...	...	...	...	...	...	...
IV	0·4581	...	...	...	...	51·0	17·8	760·0	13·14	...	...	...	...	...	...	...	...	...
V	0·3834	...	...	...	...	...	...		...	0 0523	13·64	...	...	...	...	...	...	...
VI	0·4092	...	...	...	...	...	...	...	...	0·0561	13·70	...	...	...	...	...	...	...
VII	0·5884	...	...	...	...	...	...	...	...	...	...	0·0255	0·59	...	...	...	...	...
VIII	0·5227	...	...	...	...	...	...	...	...		...	0·0243	0·63	...	...	...	...	...
IX	0·4092	...	...	...	...	...	...	...	...	...	...	...	...	0·0379	2·58	...	...	...
X	0·5884	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·0537	2·54	0
XI	0.5227	...	...	...	...	...	...	...			...	...	...	...	...	0·0501	2·67	0·09

Percentage composition of the ash-free substance.

							Average
C	51·18	51·12		...	...	.	51·1[illegible]
H	7·13	7·24	...	...	...	.	7·18
N		...	15·12	15·20	...		15·16
S	...		...	...	0·69	0·73	0·71
P	...	...	...	...			0
O		...		...	...	...	25·80

It is to be seen from the table of analytical results that the total phosphorus is exactly equal to the phosphorus of the ash. The ash, as examination showed, was composed almost entirely of calcium phosphate with a trace of iron. There was no calcium sulphate. Taking the percentage of phosphorus at the highest figure, viz: 2·67, and calculating it to calcium phosphate $Ca_3(Po_4)_2$, it would be equal to 13·3 per cent. of calcium phosphate, or within 0·3 per cent. of the ash found. Hence, it would appear that the phosphorus present in the substance probably existed there wholly as calcium phosphate.

Digestion B.

A quantity of pure casein, equal in amount to that used in digestion *A*, was warmed at 40° C. with seven litres of 0·4 per cent. hydrochloric acid, to which a quantity of purified and vigorous pepsin solution was added. After being kept at 40° C. for fifty hours, two litres more of 0·4 per cent. hydrochloric acid, together with some pepsin solution, were added and the mixture warmed at 40° C. for two days more, after which it was diluted with water and the undigested residue allowed to settle out. The supernatant fluid was syphoned off, the residue washed by decantation and then again treated at 40° C. with five litres of an active pepsin-hydrochloric acid solution for four days. The residue still undigested was filtered off, washed with water, dissolved in one per cent. sodium carbonate solution and the alkaline fluid filtered from the small amount of undissolved matter. From this fluid, the dyspeptone was precipitated by hydrochloric acid, the acid compound washed thoroughly with water, after which it was warmed at 40° C. for forty-eight hours with 1200 c. c. of 0·2 per cent. hydrochloric acid, and 50 c. c. of a strong pepsin solution. The undigested residue, after being thoroughly washed, was dissolved in 800 c. c. of one per cent. sodium carbonate, the solution exactly neutralized with hydrochloric acid and dialyzed until chlorides were entirely removed. The clear aqueous solution was evaporated to a syrup and the dyspeptone precipitated with alcohol, after which it was treated exactly as preparation *A*. 0·5 grams of pure, dried substance were obtained.

For analysis, the dyspeptone was dried at 110° C. until of constant weight. The analytical results are shown in the accompanying table.

The ash which was larger than in the first preparation, contained no sulphate whatever, but was composed in great part of calcium phosphate.

Dyspeptone B.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	T. C.	Pressure mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ after fusion with $KOH+KNO_3$ gram.	S %	$Mg_2P_2O_7$ from the Ash. gram.	P of Ash. %	$Mg_2P_2O_7$ after fusion with $KOH+KNO_3$. gram.	P %	P after deducting P of Ash. %
I	0·4220	0·2385	6·28	0·6680	43·16													
II	0·2814	0·1582	6·25	0·4465	43·27													
III	0·4918					55·1	20·2	754·7	13·02									
IV	0·3221					35·4	20·1	758·9	12·84									
V	0·4145					47·0	19·4	758·1	13·26									
VI	0·5141									0·0791	15·38							
VII	0·4898									0·0756	15·45							
VIII	0·5304											0·0223	0·58					
IX	0·5040											0·0228	0·62					
X	0·4893													0·0484	2·76			
XI	0·6304															0·0633	2·80	0·04
XII	0·6056															0·0586	2·72	0

Percentage composition of the ash-free substance.

								Average
C	51·02	51·13						*51·07*
H	7·42	7·40						*7·41*
N			15·40	15·23	15·62			*15·41*
S						0·69	0·73	*0·71*
P								*0*
O								*35·40*
								100·00

Digestions C and D.

These digestions were conducted in much the same manner as the preceding. In *C*, the casein was first subjected to the action of four litres of vigorous, but purified, artificial gastric juice containing 0·4 per cent. acid, for four consecutive days. The undigested residue was then filtered off, washed, and again treated with a vigorous pepsin-acid mixture for three days longer, in both cases at 40° C. The residue still undigested was washed thoroughly with water and then dissolved in one per cent. sodium carbonate, after which it was treated exactly as preparation A.

In *D*, the casein was warmed for three days with six litres of a similar pepsin-acid mixture, when the undissolved residue, after being filtered and thoroughly washed, was dissolved in diluted sodium carbonate and reprecipitated by dilute hydrochloric acid. Then, as in *B*, the washed précipitate was redigested with a vigorous gastric juice for several days and the residue again dissolved, after thorough washing, in one per cent. sodium carbonate and treated exactly as the preceding preparation.

For analysis, both products were freed entirely from fat, and ultimately dried at 110° C., until of constant weight. Their composition is shown in the accompanying tables.

Three other distinct preparations of dyspeptone were made in manner similar to the preceding, except that in all, larger quantities of pepsin-hydrochloric acid were employed and the mixtures warmed for a longer time at 40° C. Thus in digestion *E*, 1562 grams of moist casein were warmed with 9·5 litres of 0·4 pér cent. hydrochloric acid and pepsin for two days, and the undigested residue again treated at 40° C. with 3 litres of a like pepsin-acid for seven days, and finally treated a third time with pepsin and acid for four days, before solution in sodium carbonate, etc. Likewise in digestion *G*, 2000 grams of moist casein were warmed at 40° C. with 11 litres of 0·4 pér cent. acid and pepsin for 21 days and the residue warmed again at 40° C. for several days, with a fresh pepsin-acid mixture. Ultimately, all of the three products were treated as previously described, and finally dried at 110° C. prior to analysis. The analytical results are shown in the accompanying tables.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found c. c.	N found T. °C.	N found Pressure m m	N %	Ash found. gram.	Ash %	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	$Mg_2P_2O_7$ from the ash gram.	P of ash %	$Mg_2P_2O_7$ after fusion with $KOH + KNO_3$. gram.	P %	P after deducting P of ash. %
I	0·3603	0·2068	6·38	0·5946	45·03	----	----	----	----	----	----	----	----	----	----	----	----	----
II	0·2349	0·1341	6·34	0·3857	44·80	----	----	----	----	----	----	----	----	----	----	----	----	----
III	0·6983	----	----	----	----	78·8	18·4	759·5	13·28	----	----	----	----	----	----	----	----	----
IV	0·4780	----	----	----	----	54·9	18·8	756·8	13·44	----	----	----	----	----	----	----	----	----
V	0·5470	----	----	----	----	----	----	----	----	0·0680	12·43	----	----	----	----	----	----	----
VI	0·5655	----	----	----	----	----	----	----	----	0·0703	12·43	----	----	----	----	----	----	----
VII	0·5733	----	----	----	----	----	----	----	----	----	----	0·0245	0·58	----	----	----	----	----
VIII	0·5908	----	----	----	----	----	----	----	----	----	----	0·0262	0·60	----	----	----	----	----
IX	0·5655	----	----	----	----	----	----	----	----	----	----	----	----	0·0469	2·31	----	----	----
X	0·5733	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0·0508	2·47	0·16
XI	0·5908	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0·0524	2·47	0·16

Percentage composition of the ash-free substance.

							Average
C	51·40	51·18	----	----	----	----	*51·29*
H	7·28	7·24	----	----	----	----	*7·26*
N	----	----	15·16	15·31	----	----	*15·23*
S	----	----	----	----	0·67	0·69	*0·68*
P	----	----	----	----	----	----	*0*
O	----	----	----	----	----	----	*25·54*
							100·00

DYSPEPTONE D.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	T.°C.	Pressure m m.	N %	Ash found. gram.	Ash %	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	$Mg_2P_2O_7$ from the ash. gram	P of ash %	$Mg_2P_2O_7$ after fusion with $KOH + KNO_3$. gram.	P %	P after deducting P of ash. %
I	0·2070	0·1200	6·44	0·3390	44·66	----	----	----	----	----	----	----	----	----	----	----	----	----
II	0·2158	0·1236	6·38	0·3510	44·37	----	----	----	----	----	----	----	----	----	----	----	----	----
III	0·4238	----	----	----	----	48·0	18·4	757·8	13·29	----	----	----	----	----	----	----	----	----
IV	0·2711	----	----	----	----	30·9	20·1	757·6	13·29	----	----	----	----	----	----	----	----	----
V	0·2070	----	----	----	----	----	----	----	----	0·0294	14·20	----	----	----	----	----	----	----
VI	0·2158	----	----	----	----	----	----	----	----	0·0306	14·18	----	----	----	----	----	----	----
VII	0·6436	----	----	----	----	----	----	----	----	----	----	0·0302	0·64	----	----	----	----	----
VIII	0·5613	----	----	----	----	----	----	----	----	----	----	0·0279	0·68	----	----	----	----	----
IX	0·4228	----	----	----	----	----	----	----	----	----	----	----	----	0·0386	2·55	----	----	----
X	0·6436	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0·0554	2·40	0
XI	0·5613	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0·0508	2·52	0

Percentage composition of the ash-free substance.

							Average
C	51·97	51·68	----	----	----	----	*51·82*
H	7·47	7·41	----	----	----	----	*7·44*
N	----	----	15·48	15·48	----	----	*15·48*
S	----	----	----	----	0·76	0·80	*0·78*
P	----	----	----	----	----	----	*0*
O	----	----	----	----	----	----	*24·48*
							100·00

Dyspeptone E.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram	C %	N found c. c	T °C	Pressure mm	N %	Ash found gram	Ash %
I	0·7272	0·3758	5·74	1·1528	43·28	..			..		-
II	0·3746	0·1927	5·71	0·5967	43·17	...		...		..	
III	0·3177	..	-	- -		34·06	13·0	759·6	12·84	...	..
IV	0·5570	....	....	-	...	58 38	12·2	760·3	12·61	..	...
V	0·3319				...			- -		0·0496	14·94
VI	0·3330		..	...		. .				0·0499	14·98

Percentage composition of ash-free substance.

					Average
C	50·84	50·75	-	..	*50·80*
H	6 75	6·72	-		*6·73*
N	-		15·10	15·15	*15 12*

Dyspeptone F.

No	Substance used gram	H_2O found. gram	H %	CO found. gram	C %	N found c c	T °C	Pressure mm	N %	Ash found gram	Ash %
I	0·5375	0·2837	5·86	0·8772	44·50	- -	....		-	-	
II	0·5686	0·3039	5·93	0·9317	44·68	-		-	-		-
III	0·4649	....	-			50·3	12·4	764·0	13·11		
IV	0·4100	....	- -		...	44·7	13 0	765·5	13·16	-	-
V	0·3938	...	...		-			-		0·0536	13·61
VI	0·4347	....						..		0 0590	13 59

Percentage composition of ash-free substance.

					Average
C	51·50	51·70	-	...	*51 60*
H	6·78	6·87	...	...	*6 83*
N	....		15·17	15 21	*15·19*

Dyspeptone G.

No.	Substance used gram	H_2O found gram	H %	CO_2 found gram.	C %	N found. c c	T °C.	Pressure mm	N %	Ash found gram	Ash %
I	0·7545	0·3915	5·76	1·2148	43·90	..	- -		-	-	
II	0·4094	0·2187	5·79	0·6604	43·98	....	.. -	-	...		
III	0·6268	-	- -	...		70·6	13·8	760·5	13·56		
IV	0·7803	..	...	...	-	88·8	14·0	760·3	13·61	-	-- -
V	0·4356	....	....		-	-	....	...		0·0552	12·66
VI	0·5654	....	- -	....	- ..	...	....	...		0·0722	12·76

Precentage composition of ash-free substance.

					Average.
C	50·35	50·44	....	....	*50·39*
H	6·61	6·65	-	....	*6·63*
N	....	....	15·55	15·61	*15·58*

TABLE SHOWING THE AVERAGE COMPOSITION OF THE SEVERAL DYSPEPTONES.

	A	B.	C.	D	E	F.	G.	Casein *
C...........	51·15	51·07	51·29	51·82	50·80	51·60	50·39	53·30
H	7·18	7·41	7·26	7·44	6 78	6·83	6·63	7·07
N	15·16	15·41	15·33	15·48	15·12	15·19	15 58	15·91
S	0·71	0·71	0·68	0·78	...		...	0·82
P...........	0	0	0	0	...	..		0·87
O	25·80	25·40	25·54	24·48	...		.	22·03
Ash	13·67	15·41	12·43	14·19	14·96	13·60	12·71	0·98

It is evident from the more complete analyses of the first four products, that the dyspeptone as prepared by us contains essentially the same percentage of sulphur as the original casein; further, that instead of being a phosphorized compound, it apparently contains no phosphorus whatever, other than that combined with calcium. Very noticeable, is the large percentage of ash in all of the preparations. This we were not able to materially reduce by any process of purification, and as the ash of the original casein, like that of the dyspeptone, was composed almost wholly of calcium phosphate, it would appear as if all of the phosphate from the mother substance had attached itself to the dyspeptone.

In their content of carbon, all of the seven preparations show a very close agreement, while they differ from casein by containing two per cent. less carbon. The nitrogen of the dyspeptone is, likewise, a little less than that of casein, while the individual preparations show throughout a very close agreement in their content of this element. In composition, therefore, all of the seven preparations, although representing considerable variation in the method of production, show a sufficiently close agreement to indicate their identity. Compared with casein, the lower percentage of carbon would point to their production by hydration, and it would appear from the analytical data that the so-called casein dyspeptone, formed by gastric digestion, is a mixture of calcium phosphate with a hydration product of casein,

* Chittenden and Painter Studies from Laboratory, vol ii, p. 173.

the hydrochloric acid compound of which is insoluble in water and dilute acid. The dyspeptone itself is quite readily soluble in cold water, the solution remaining unchanged on boiling.

Following are some of the reactions of dyspeptone.

Addition of acetic acid to an aqueous solution of the substance produces a heavy white precipitate insoluble in moderate excess, but partially soluble in a large excess of the acid. On heating the strongly acid fluid, the precipitate dissolves completely and the fluid remains clear on cooling. Addition of potassium ferrocyanide to the clear acid fluid gives only a slight turbidity.

Dilute hydrochloric and sulphuric acid both give a heavy white precipitate, insoluble in slight excess of acid, but entirely soluble in a large excess on application of heat. Even 0·2 per cent. hydrochloric acid precipitates the dyspeptone completely.

Dilute nitric acid, likewise, precipitates the dyspeptone, but the precipitate is far more soluble in excess of the acid. On warming the acid solution, it quickly turns yellow, and with ammonia gives the orange yellow color of the xanthoprotein reaction.

Cupric sulphate and potassium hydroxide give the violet color of the biuret reaction.

Cupric sulphate and ferric chloride both give heavy precipitates, insoluble in excess.

Potassium hydroxide and lead acetate give, on boiling, a distinct reaction for sulphur.

Mercuric chloride, added in small quantity to a cold aqueous solution of the dyspeptone, gives no precipitate, but when added in excess and the mixture is heated, a heavy white precipitate is formed, insoluble on cooling.

The dyspeptone is precipitated by saturation of its aqueous solution with ammonium sulphate, but not by sodium chloride, even on heating. Addition of acetic acid, however, to the salt-saturated fluid gives the usual precipitate of dyspeptone.

Casein antialbumid.

On heating casein with sulphuric acid and water at 100° C., it is decomposed, as is well known, into soluble products and an insoluble antialbumid. We have found, however, that the antialbumid prepared in this manner is quite different in composition from the dyspeptone formed in gastric digestion. In one experiment, where about two kilograms of pure, moist casein were heated with two litres of water and 100 grams of concentrated sulphuric acid for seven hours

at 100° C., and the residue so obtained treated again in a like manner with the same strength of acid, a comparatively large amount of casein antialbumid was obtained, which unlike the dyspeptone from a gastric digestion, was only slowly soluble in dilute sodium carbonate. Freed from any adhering soluble products by treatment with several litres of a vigorous gastric juice for two days at 40° C., it still dissolved slowly in dilute sodium carbonate. By long contact with a one per cent. solution of the alkaline carbonate it finally dissolved, leaving but a small residue. From this solution, the antialbumid was reprecipitated by hydrochloric acid, and after thorough washing with water, it was again dissolved in sodium carbonate, the fluid made exactly neutral and then dialyzed until all chloride was removed. After concentration of the fluid and precipitation with alcohol, etc., the antialbumid was dried and analyzed. It contained 18 per cent. of ash. The ash-free substance contained 54·4 per cent. of carbon, 6·8 per cent. of hydrogen, and 14·8 per cent. of nitrogen; showing thus a much higher percentage of carbon, and a lower percentage of nitrogen than the dyspeptone formed by pepsin-hydrochloric acid.

Both casein antialbumid and dyspeptone are dissolved with more or less readiness by alkaline solution of trypsin and are converted by long warming at 40° C. into a peptone-like body, presumably antipeptone.

II. *Caseoses;— from experiments by Charles Norris, Jr., Ph.B., and C. A. Tuttle, Ph B.*

In a previous study of the caseoses formed in pepsin digestion,* we were much impressed with the peculiar behavior of protocaseose towards acids. Unlike the proto bodies from other proteids previously studied, *aqueous* solutions of the substance gave heavy precipitates with dilute acids. Protocaseose, as then separated, was readily soluble in 0·4 per cent. hydrochloric acid, but addition of stronger acid invariably produced a decided precipitate, soluble, however, in a still larger excess of acid. This peculiarity rendered the protocaseose an object of some interest to us, and further study of the conditions favoring its formation in gastric digestion has shown us that, apparently, the nature of the body precipitated by saturation with salt, as well as the body precipitated by salt-saturated acetic acid is modified by the strength of the pepsin solution,

* Chittenden and Painter Studies from Laboratory of Physiological Chemistry, vol. II, p 195.

and the length of time the casein is subjected to the action of the ferment. In our earlier work with the proteoses, we deemed it essential in attempting a study of the primary products of proteolytic action to use as weak a ferment solution as possible, and to discontinue its action as soon as solution of the proteid was complete, in order that there might not be too great a loss through formation of peptone. Further study, however, especially by use of the ammonium sulphate reaction, has shown us that the formation of peptone is a far less rapid process than generally supposed. Indeed, in the majority of artificial digestions with pepsin-hydrochloric acid, as ordinarily conducted, the ammonium sulphate reaction will show the entire absence of peptone True peptone appears to be formed only by the action of a very vigorous pepsin mixture and that long continued.

In all of our previous experiments, the casein was either subjected to the action of a very weak pepsin mixture or else, in the use of a stronger ferment, exposed to its action for a few hours only. We now find that by using a far more vigorous pepsin mixture and by continuing its action for several days instead of hours, there is still not a trace of peptone to be found in the filtrate from the ammonium sulphate precipitate of the caseoses, but that the caseoses themselves, particularly the proto and deuterocaseose, differ somewhat, both in composition and reactions from the products previously separated. The discovery of this fact has led us to a further study of the caseoses formed in pepsin digestion, by which we have been able in many ways to verify our former observations and at the same time extend our knowledge of these interesting primary cleavage products of casein. We have also extended our work by studying the caseoses formed through the action of trypsin, and dilute sulphuric acid.

A. Caseoses formed by pepsin-hydrochloric acid.

In all of these experiments the pepsin mixture was very powerful, and was especially prepared to insure freedom from both albumoses and peptone.* The casein was, likewise, thoroughly pure, having been freshly prepared from skim milk by precipitation with 0·2 per cent. hydrochloric acid, and reprecipitation three or four times after solution in ammoniacal water.

* Studies from the Laboratory of Physiological Chemistry, vol. ii, p 133.

Digestion A.

Nearly 2 kilos. of moist casein were warmed at 40° C. for a little more than two days, with 10 litres of 0·4 per cent. hydrochloric acid containing sufficient of the pepsin mixture to insure vigorous action. After partial neutralization of the acid, the clear fluid was filtered from the semi-gelatinous dyspeptone, made exactly neutral with sodium hydroxide and then evaporated until moderately concentrated. On filtering the concentrated fluid through paper, a small residue remained, somewhat gummy, insoluble in dilute acid, but readily soluble in dilute sodium carbonate, from which it was precipitated by either hydrochloric or acetic acid. The amount was too small for study, but it seemed to resemble in reactions casein dyspeptone.

The neutral fluid containing the caseoses gave no precipitate whatever on addition of 0·4 per cent. hydrochloric acid or even stronger acid, and in this respect differs from the earlier digestions in which the ferment action was continued for a short time only. With dilute acetic acid, however, a slight turbidity was produced, the amount of which was too small to admit of any study of its character.

The caseoses were precipitated collectively in the form of a heavy gummy precipitate, by saturation of the neutral fluid with ammonium sulphate. On boiling the filtrate from this ammonium sulphate precipitate, a small quantity of a second gummy precipitate was obtained. In the filtrate from this second precipitate, no trace of a peptone-like body could be discovered by any of the ordinary tests. Apparently only caseose bodies had been formed.

The first and main ammonium sulphate precipitate, after being washed by trituration with a saturated solution of ammonium sulphate, was dissolved in water and the perfectly neutral fluid saturated in the cold with sodium chloride. By this means a heavy gummy precipitate was formed, which after being washed with a saturated solution of sodium chloride was redissolved in water, and reprecipitated by saturation of the neutral fluid with salt. After three or four reprecipitations, the protocaseose was considered sufficiently pure.

In this digestion, there appeared to be present more heterocaseose and dyscaseose than in our former experiments, as was evidenced by the small insoluble residues remaining each time the precipitated protocaseose was redissolved in water. These residues of hetero- and

dyscaseose were very small, but still sufficiently large to enable us to make out their general characters. Similarly, Dr. Thierfelder* found in the purification of his protocaseose, or "propeptone I" as he terms it, a small, insoluble residue each time he dissolved the sodium chloride precipitate in water. It would appear, therefore, that in a vigorous or long continued digestion there is a much greater probability of the hetero body being formed than when the ferment is allowed to act only a short time on the casein. This, however, is contrary to Neumeister's views regarding the order of formation of the proteoses.

In order to free the precipitated protocaseose from salt and any adhering heterocaseose, it was dissolved in water and dialyzed until all chloride was removed. The neutral solution was then concentrated to a syrup, and the proto body precipitated by alcohol. During the concentration of the fluid, a gummy-like mass separated, similar to the separation of protoelastose. This, however, dissolved more or less completely as the mixture cooled. The precipitated caseose, after being extracted several times with alcohol and with warm ether, was partially dried, ground to a fine powder, re-extracted with ether in a fat extractor and finally dried at 110° C. until of constant weight.

On analysis it gave the following results:

Protocaseose A.

I. 0·4947 gram substance gave 0·9794 gram CO_2=53·98 per cent. C.

II. 0·3802 gram substance gave 0·2397 gram H_2O=7·00 per cent. H.

III. 0·3862 gram substance gave 0·2467 gram H_2O=7·09 per cent. H and 0·7670 gram CO_2=54·15 per cent. C.

IV. 0·4953 gram substance gave 64·8 c. c. N at 20·8° C. and 760·3 mm pressure=15·72 per cent. N.

V. 0·3764 gram substance gave 50·1 c. c. N at 22·5° C. and 760·6 mm pressure=15·95 per cent. N.

VI. 0·4599 gram substance gave 0·0046 gram ash=1·00 per cent.

VII. 0·4103 gram substance gave 0·0041 gram ash=0·99 per cent.

Percentage composition of ash-free substance.

						Average
C	54·53	54·69	....	....	.	54·61
H	...	7·11	7·07	....	....	7·11*
N	....	.. .	....	15·88	16·11	15·99

* Zur Kenntniss der Caseinpeptone, Zeitschrift für physiologische Chemie, x, p. 577

This protocaseose is thus seen to have a higher percentage of carbon than the proto bodies previously* studied, although one product was then obtained with 53·93 per cent. C, 7·17 per cent. H, and 16·05 per cent. N.

In reactions, likewise, this protocaseose differs somewhat from the protocaseoses previously obtained, and as the characters of the present body have been verified by the reactions of several other products similarly produced, we are led to believe in their constancy. Moistened with water, the powdered protocaseose becomes immediately gummy and soon dissolves to a perfectly clear fluid, which on addition of considerable water becomes decidedly cloudy or turbid. Treated with a large amount of water at the outset, the protocaseose dissolves more slowly, giving a more or less turbid fluid. In dilute acid and in dilute sodium carbonate it dissolves to a perfectly clear fluid.

Towards heat, aqueous solutions of protocaseose act exactly like protoelastose. Even when warmed very gently, the solution becomes quickly turbid and if concentrated gives more or less of a flocculent precipitate. On cooling, the turbidity disappears, reappearing as the fluid is heated. Like protoelastose also, a solution of the caseose body on being rapidly concentrated deposits more or less of the substance as a gummy mass, which, however, will dissolve in cold water, or if the fluid is not too concentrated will dissolve in the mother liquid as it cools. Dilute acetic acid added to an aqueous solution of protocaseose gives no precipitate whatever, but potassium ferrocyanide added to the acid fluid gives a heavy precipitate.

Dilute hydrochloric acid produces no precipitate

Dilute nitric acid added to an aqueous solution of the caseose gives a heavy white precipitate, which on gently warming, quickly dissolves while the fluid takes on a faint pink or rose color, which on further warming changes to a bright yellow or reddish yellow color. If the nitric acid solution is not warmed too long, the precipitate reappears as the mixture cools.

Solution of cupric sulphate gives a heavy, greenish white precipitate when added to an aqueous solution of protocaseose.

As already stated, the first precipitates of protocaseose obtained by saturating the neutralized digestive fluid with salt, were not entirely soluble in water; a small residue remained, apparently

* See Chittenden and Painter Studies from Laboratory of Physiological Chemistry, Yale University, vol ii, p 107

wholly insoluble. This residue, which by analogy should consist of hetero and dyscaseose was somewhat soluble in salt solution and wholly soluble in dilute sodium carbonate and dilute acid, both acetic and hydrochloric, even dissolving in 0·2 per cent. hydrochloric acid. It was dissolved in sodium carbonate, the fluid neutralized without giving any precipitate, and dialyzed until the sodium chloride was entirely removed. The neutral and clear fluid was then concentrated to a syrup, precipitated by alcohol and the precipitate dried at 110° C. On treatment with cold water, it was now found soluble to a large extent, though a certain amount of gummy matter was still insoluble. The soluble portion showed all of the reactions of the proto body; the solution being rendered turbid by heat, clear again on cooling, and giving in the cold a heavy precipitate with nitric acid, soluble when heated. This behavior of the insoluble heterocaseose towards dilute sodium carbonate would seem to imply a conversion of this substance into protocaseose, or perhaps a reconversion of the coagulated heterocaseose dyscaseose, into heterocaseose proper.

Acetic acid precipitate.

On adding a little 30 per cent. acetic acid to the original salt-saturated filtrate from the first sodium chloride precipitate of protocaseose, etc., a heavy, flocculent precipitate settled out, which in amount far exceeded the protocaseose and which on standing, soon became gummy. Excess of acid was avoided, as the precipitate was somewhat soluble in a large amount of the reagent. The gummy mass, after being washed as thoroughly as possible with saturated salt solution, was treated with cold water, in which the greater portion of the substance dissolved, the solution made neutral, dialyzed, concentrated to a syrup, and the substance precipitated with alcohol. It was then thoroughly extracted with ether and finally dried at 110° C.

In reactions, it differed decidedly from protocaseose; in water it was quickly and completely soluble and the solution when heated gave no coagulum whatever, or at the most only the slightest approach to a turbidity.

Dilute nitric acid, in the cold, gave no precipitate; when heated, the acid fluid changed to a reddish yellow color, which quickly turned yellow.

With acetic acid, an aqueous solution of the substance remained perfectly clear. Potassium ferrocyanide, however, when added to the acid fluid gave a heavy precipitate.

Saturation of the aqueous solution with salt gave a slight turbidity.

Cupric sulphate gave a heavy precipitate, soluble in excess.

On analysis, the substance gave the following results, which show a composition quite different from that of protocaseose.

Acetic Acid Precipitate A.

I. 0·4629 gram substance gave 0·2812 gram H_2O=6·74 per cent. H and 0·8608 gram CO_2=50·71 per cent. C.

II. 0·3277 gram substance gave 0·1977 gram H_2O=6·70 per cent. H and 0·6050 gram CO_2=50·34 per cent. C.

III. 0·4253 gram substance gave 53·1 c. c. N at 13·0° C. and 761·8 mm pressure=15·01 per cent. N.

IV. 0·4843 gram substance gave 60·8 c. c. N at 13·0° C. and 760·8 mm pressure=15·07 per cent. N.

V. 0·3649 gram substance gave 0·0108 gram ash=2·96 per cent.

VI. 0·3947 gram substance gave 0·0124 gram ash=3·14 per cent.

Percentage composition of ash-free substance

					Average
C	52·30	51·92	...	...	52·10
H	6·96	6·90	..	....	6·93
N	..		15·48	15·54	15·51

As previously stated, the above original precipitate produced by acetic acid was not entirely soluble in water. A small residue remained, which after being washed with water was dissolved in dilute sodium carbonate, and the solution neutralized with dilute hydrochloric acid, without yielding any neutralization precipitate. The solution was then dialyzed, concentrated to a syrup and the substance precipitated by alcohol. It was now found, to a great extent, soluble in water, the solution showing no turbidity by heat and giving no precipitate with nitric acid. Cupric sulphate gave a heavy precipitate, and dilute acetic acid added to the aqueous solution produced quite a heavy precipitate, not readily soluble in excess of the acid. The amount of substance was too small to admit of analysis, and the reactions are hardly sufficient to identify it. It is evidently not heterocaseose, for it is only the acetic acid compound that is insoluble in water, not the caseose substance itself. In many respects it appears like casein dyspeptone, and as this substance is precipitated by saturation of its aqueous solution with ammonium sulphate and not by sodium chloride, the presence of a trace of this body might not be impossible.

Ammonium sulphate precipitate.

On adding ammonium sulphate in substance to the above salt-saturated acetic acid fluid, a slight gummy precipitate was obtained, readily and completely soluble in water, and which, after removal of the salts by dialysis and concentration of the fluid, was precipitated by alcohol. In reactions it did not differ materially from the body obtained by precipitation with acetic acid, except that with cupric sulphate only a slight precipitate was produced. With acetic acid and potassium ferrocyanide, on the other hand, a distinct precipitate was obtained, while with nitric acid in the cold no turbidity whatever was produced.

In composition, however, it differed decidedly from the preceding preparations, although as it contained considerable ash, nearly 10 per cent., the result perhaps can be considered only as an approximation to the truth.

Following is the percentage composition of the ash-free substance:

					Average.
C	48.38	48·18	..	....	*48·23*
H	6·88	7·01	-	....	*6·94*
N			15·63	15·75	*15·69*

This body, which by analogy should be nearly pure deutero-caseose, evidently approaches much nearer to our conception of a true casein peptone than any of the preceding preparations. Another body, however, has been obtained with a still lower content of carbon and with reactions still more closely approximating to true peptone.

In the first precipitation of the caseoses from this digestion by saturation of the original fluid with ammonium sulphate, it will be remembered that a small amount of a second gummy precipitate was obtained on heating the cold saturated ammonium sulphate filtrate. This gummy precipitate of a caseose body, after purification by dialysis and precipitation with alcohol, was found to consist of a substance extremely soluble in water, the solution giving no precipitate with acetic acid and potassium ferrocyanide, neither with nitric acid nor with cupric sulphate. After being dried at 110° C. it gave on analysis the following results:

I. 0·7280 gram substance gave 0·4239 gram H_2O=6·46 per cent. H and 1·2160 grams CO_2=45·54 per cent. C.

II. 0·5020 gram substance gave 0·2905 gram H_2O=6·40 per cent. H and 0·8442 gram CO_2=45·85 per cent. C.

III. 0·3291 gram substance gave 42·1 c. c. N at 13·9° C. and 756 mm pressure=15·33 per cent. N.

IV. 0·6835 gram substance gave 87·0 c. c. N at 14·5° C. and 756 mm pressure=15·30 per cent. N.

V. 0·5370 gram substance gave 0·0230 gram ash=4·28 per cent.

VI. 0·3525 gram substance gave 0·0154 gram ash=4·36 per cent.

Percentage composition of ash-free substance

					Average.
C	47·57	47·87		....	*47·72*
H	6·75	6·70	.		*6·73*
N			15·99	15·96	*15·97*

This substance, since it is precipitable by ammonium sulphate, cannot be considered a true peptone, yet in composition it closely approaches both the ampho- and antipeptone from fibrin,* which it also resembles somewhat in reactions, except in its behavior towards ammonium sulphate.

It is thus evident from the foregoing, that in this active and comparatively long continued digestion there is a much smaller amount of protocaseose present than was found in our former experiments. Indeed, deuterocaseose appears to predominate, while at the same time the protocaseose is modified both in composition and reactions, due in part without doubt, to adhering heterocaseose. Further, we are inclined to consider the presence of at least two forms of deuterocaseose. We have generally considered that a proto body is never completely precipitated by saturation of its aqueous solution with salt, and that consequently the precipitate produced by acid in the salt-saturated fluid must be a mixture of proto and deuteroproteose, and this we have usually found to be the case. In the present digestion, however, the acetic acid precipitate contained only a very small amount of protocaseose, for as previously stated this precipitate when purified gave only a slight turbidity on saturation of its aqueous solution with salt and no precipitate whatever with nitric acid; both of which reactions would indicate freedom from any large amount of protocaseose. This view is further substantiated by the great difference in the percentage of carbon of the two bodies. To be sure we have, with Neumeister, looked on the cupric sulphate reaction as a means of distinguishing between proto and deuteroalbumose, but it does not necessarily follow that the same reaction will hold good for all proteoses. The acetic acid precipitate does indeed give a strong

* Kühne and Chittenden, Studies, vol. ii, p 40.

reaction with cupric sulphate, but the striking differences in composition and reactions between the purified sodium chloride precipitate and the acetic acid precipitate (when freed from acid) point to a totally different nature, and we are inclined to consider the latter as a deutero body, probably contaminated with a little protocaseose, and for convenience we propose to call it *α* deuterocaseose.

It is unquestionably very difficult, if not almost impossible, to isolate the individual caseoses in a state of perfect purity. Whenever one is precipitated, it usually brings down with it more or less of any other caseose present and such admixtures are very hard to remove. It is, we think, owing to this fact that we have not been able to obtain *α* deuterocaseose sufficiently free from protocaseose as not to give any precipitate on saturation with sodium chloride.

That form of caseose in this digestion which was not precipitated by salt, or by salt and acetic acid, but which appeared on addition of ammonium sulphate in the cold, is probably a mixture of *α* deutero and and what we term *β* deuterocaseose, with possibly an intermediate body.

The name *β* deuterocaseose, we apply to that caseose not readily precipitable by saturation with ammonium sulphate in the cold, and which is generally found in a greater or less quantity in the filtrate from the precipitate produced by saturation with ammonium sulphate. It is precipitated fairly pure, as a sticky gum, by simply boiling the saturated ammonium sulphate filtrate and is especially characterized by its low content of carbon, and by its non-precipitation with acetic acid and potassium ferrocyanide, with nitric acid, and with cupric sulphate. It stands, unquestionably, nearer to peptone than *α* deuterocaseose and is doubtless formed from the latter by the continued action of the ferment.

Digestion B.

In this digestion, 2 kilos. of moist casein were warmed at 40° C. for eight days, with about 5 litres of 0·4 per cent. hydrochloric acid containing an active pepsin solution, after which the mixture was partially neutralized with sodium carbonate and filtered from the dyspeptone. The clear fluid was then made exactly neutral (no neutralization precipitate) and concentrated to a thin syrup. When cold, proto and heterocaseose were directly precipitated by saturation of the solution with salt. Protocaseose was purified by repeated precipitation with salt, etc., as described under *A*. In this process, the same insoluble residues of hetero and dyscaseose were met with

as in the previous digestion The purified protocaseose showed the same peculiar reactions as protocaseose *A*., viz: with nitric acid a heavy white precipitate, soluble on warming; with heat alone, a distinct turbidity or coagulum, disappearing as the solution cooled; and giving with a large amount of water a more or less turbid fluid, from which on standing a little gummy matter separated.

Dried at 110° C. and analyzed, the following results were obtained.

Protocaseose B.

I. 0·3470 gram substance gave 0·2192 gram H_2O = 7·02 per cent. H.

II. 0·2935 gram substance gave 0·1854 gram H_2O = 7·01 per cent. H and 0·5779 gram CO_2 = 53·69 per cent. C.

III. 0·2952 gram substance gave 0·5853 gram CO_2 = 54·07 per cent. C.

IV. 0·2980 gram substance gave 38·8 c. c. N at 13·8° C. and 760·1 mm pressure = 15·52 per cent. N.

V. 0·5564 gram substance gave 72·8 c. c. N at 13·1° C. and 760·1 mm pressure = 15·69 per cent N.

VI. 0·3594 gram substance gave 0·0047 gram ash = 1·30 per cent.

VII. 0·3523 gram substance gave 0·0045 gram ash = 1·27 per cent.

Percentage composition of ash-free substance

						Average.
C		54·77	54·39	..		54·58
H	7·10	7·09			.	7·10
N			....	15·71	15·90	15·80

In composition, therefore, as in reactions, this body is apparently identical with protocaseose *A*.

In the original salt-saturated filtrate from protocaseose, acetic acid produced a heavy, gummy precipitate, which was dissolved in water and purified in the same manner as the corresponding body in digestion *A*. Like the latter, it was readily and completely soluble in water, the solution giving no turbidity whatever by heat, nor on the addition of either nitric or acetic acid. With cupric sulphate, a heavy precipitate was formed, as also with acetic acid and potassium ferrocyanide.

Dried at 110° C. it gave the following results on analysis:

Acetic acid precipitate B.

I. 0·3429 gram substance gave 0·2057 gram H_2O = 6·66 per cent. H and 0·6315 gram CO_2 = 50·22 per cent. C.

II. 0·4345 gram substance gave 0·2734 gram H_2O=6·72 per cent. H and 0·8358 gram CO_2=50·48 per cent. C.

III. 0·3316 gram substance gave 43·5 c. c. N at 13·7° C. and 756·3 mm pressure=15·70 per cent. N.

IV. 0·3258 gram substance gave 43·1 c. c. N at 13·2° C. and 759·1 mm pressure=15·86 per cent. N.

V. 0·3306 gram substance gave 0·0126 gram ash=3·81 per cent.

VI. 0·2262 gram substance gave 0·0085 gram ash=3·76 per cent.

Percentage composition of ash-free substance.

					Average
C	52·17	52·43	...	.	*52·30*
H	6·92	6·99	.		*6·95*
N	.	. .	16·32	16·49	*16·40*

This body appears to differ from *a* deuterocaseose obtained in digestion *A* by nearly 1 per cent. of nitrogen, but in all other respects is practically identical with it.

As in digestion A, the precipitate first obtained by the addition of acetic acid was not entirely soluble in water, a residue remained soluble in dilute sodium carbonate, and which comported itself exactly like the insoluble residue obtained in the preceding digestion, apparently being a trace of casein dyspeptone.

The original filtrate from the above acetic acid precipitate, on saturation with ammonium sulphate, gave an additional precipitate, hardly sufficient for analysis, but which when purified proved to be identical with the corresponding body from *A* and like it giving with cupric sulphate only a very slight precipitate.

It is thus seen that in a vigorous pepsin digestion of casein there are formed, in addition to dyspeptone and heterocaseose, at least three distinct caseoses all soluble and differing from each other both in composition and reactions. As compared with casein, protocaseose is somewhat peculiar in containing a higher percentage of carbon than the mother substance. All of the other products show a very much smaller content of carbon. The relative composition of the products is shown in the following table:

	Casein	*Proto-caseose A.*	*Proto-caseose B*	*a Deutero-caseose A.*	*a Deutero-caseose B.*	*β Deutero-caseose A.*
C	53·30	54·61	54·58	52·10	52·30	47·72
H	7·07	7·11	7·10	6·93	6·95	6·78
N	15·91	15·99	15·80	15·51	16·40	15·97

Protocaseose agrees closely in its content of carbon with the "propeptone I" of Thierfelder.* This investigator has separated from a pepsin digestion of casein, by a process similar to our method of separating the proto body, a substance to which he gives the above name and which contained 54·63 per cent. of carbon and 7·45 per cent. of hydrogen. In reactions it was similar to protocaseose, except that aqueous solutions of the substance remained perfectly clear on warming. Nitrogen was not determined. Thierfelder also separated from the filtrate from his "propeptone I," a second body, by addition of hydrochloric acid, to which he gives the name "propeptone II." This substance, which corresponds to our *α* deuterocaseose, he found to contain 49·8 per cent. carbon, 7·18 per cent. hydrogen and 14·23 per cent. nitrogen. Judging from the method of separation, however, the body analyzed must have been an acid compound of the caseose and not the caseose body itself. In reactions, so far as they are given, the substance was not different from *α* deuterocaseose.

b Caseoses from Weyl's casein peptone.

This commercial product, sent to us from Germany, we have examined according to the foregoing methods and have found it, as might be expected, composed almost entirely of caseoses. It was completely soluble in water and gave with acetic acid a slight turbidity, somewhat increased by addition of potassium ferrocyanide. By saturation of its aqueous solution with sodium chloride, only a comparatively small precipitate was obtained, greatly increased, however, by addition of acetic acid.

200 grams of the powder were dissolved in water and the caseoses precipitated collectively by saturation of the fluid with ammonium sulphate, in the form of a heavy gummy precipitate. On heating the filtrate from this precipitate of caseoses until a crust of ammonium sulphate formed on the surface of the hot fluid, a second gummy precipitate gradually separated, which after purification by dialysis, etc., was finally precipitated by alcohol, and a portion dried at 110° C. for analysis.

This substance, representing a form of caseose not readily precipitable by ammonium sulphate and thus indicating its close approach to true peptone, is apparently identical with the *β* deuterocaseose similarly obtained in our own digestion, but present here in much

* Zeitschrift für physiologische Chemie, Band x, p. 585.

larger quantity. In water it was readily and completely soluble, the solution giving no turbidity whatever by heat, nor with dilute nitric acid. With cupric sulphate only a very slight turbidity was produced, and with acetic acid and potassium ferrocyanide a correspondingly slight turbidity. Its aqueous solution on being saturated with salt and then made slightly acid with acetic acid showed a small flocculent precipitate, doubtless representing the substance which gave the slight turbidity with cupric sulphate and potassium ferrocyanide, viz: α deuterocaseose. On analysis the following results were obtained:

β deuterocaseose from Weyl's casein peptone.

I. 0·3641 gram substance gave 0·2121 gram H_2O=1·47 per cent. H and 0·6087 gram CO_2=45·58 per cent. C.

II. 0·4600 gram substance gave 0·2708 gram H_2O=6·54 per cent. H and 0·7652 gram CO_2=45·36 per cent. C.

III. 0·3298 gram substance gave 42·2 c. c. N at 13·9° C. and 755·4 mm pressure =15·31 per cent. N.

IV. 0·3418 gram substance gave 43·5 c. c. N at 14·4° C. and 756·1 mm pressure =15·31 per cent. N.

V. 0·3514 gram substance gave 0·0153 gram ash =4·35 per cent.

VI. 0·3599 gram substance gave 0·0155 gram ash =4·30 per cent.

Percentage composition of ash-free substance.

					Average.
C	47·61	47·40	....	....	*47·50*
H	6·76	6·83	....	...	*6·79*
N	...	....	16·00	15·84	*15·92*

In composition, therefore, as well as in reactions, this body resembles the β deutero described under *A*, and like it is especially characterized by its exceedingly low percentage of carbon.

From the first ammonium sulphate precipitate of caseoses, protocaseose was separated by saturation of the aqueous solution of the above precipitate with salt. As in similar precipitates from the preceding digestions, there was considerable heterocaseose present, showing itself as an insoluble residue when the sodium chloride precipitate was dissolved in water for reprecipitation. Purified after the methods previously described, the protocaseose showed the usual reactions characteristic of this body, its aqueous solution growing turbid when heated, giving a precipitate with nitric acid, etc.

Dried at 110° C. it gave on analysis the following results:

Protocaseose, from Weyl's casein peptone.

I. 0·4291 gram substance gave 0·2597 gram H_2O=6·72 per cent. H and 0·8140 gram CO_2=51·70 per cent. C.

II. 0·3647 gram substance gave 0·2155 gram H_2O=6·56 per cent. H and 0·6935 gram CO_2=51·85 per cent. C.

III. 0·4115 gram substance gave 52·5 c. c. N at 13·6° C. and 760·8 mm pressure=15·11 per cent. N

IV. 0·7730 gram substance gave 96·9 c. c. N at 13·8° C. and 761·2 mm pressure=15·10 per cent N.

V. 0·2901 gram substance gave 0·0121 gram ash=4·16 per cent.

VI. 0·2959 gram substance gave 0·0120 gram ash=4·05 per cent.

Percentage composition of ash free substance

					Average
C	53·93	54·08			*54·01*
H	7·01	6·84	...		*6·92*
N	..		15·75	15·70	*15·72*

Addition of salt-saturated acetic acid to the filtrate from protocaseose, gave a moderately heavy, gummy precipitate which, after purification and removal of the acid, was completely soluble in water, the solution showing no turbidity by heat, but giving a slight turbidity with dilute nitric acid. It gave all of the reactions mentioned as characteristic of this precipitate. It was not analyzed.

The original filtrate from the acetic acid precipitate gave on saturation with ammonium sulphate, a small gummy precipitate which after purification was found wholly soluble in water, the solution giving no turbidity by heat and no precipitate with nitric or acetic acid. With acetic acid and potassium ferrocyanide, however, a distinct turbidity was produced and with cupric sulphate a heavy precipitate. The substance was not analyzed.

It is thus evident that Weyl's so-called casein peptone, however it may be prepared, contains essentially the same kind of caseoses found in our own digestions with pepsin-hydrochloric acid. In addition, a small amount of a substance was found not precipitable by saturation with ammonium sulphate and which gave no precipitate with nitric or acetic acid, nor with acetic acid and potassium ferrocyanide, and with cupric sulphate only a slight turbidity. This body, which doubtless was amphopeptone mixed with a little caseose, was obtained in too small quantity for analysis.

c. Caseoses formed by dilute sulphuric acid at 100° C.

Two kilos. of pure moist casein were heated in a flask with 2 litres of water and 100 grams of pure sulphuric acid at 100° C. for seven hours. The residue of casein and antialbumid was again warmed with a like amount of fresh acid and water for six hours. The acid fluids were united, neutralized with sodium carbonate without giving any noticeable precipitate, and then evaporated until moderately concentrated. On cooling, considerable tyrosin and leucin crystallized from the fluid. With cupric sulphate, the solution gave a heavy precipitate which dissolved in sodium hydroxide with a reddish color. Sodium chloride and ammonium sulphate both produced heavy precipitates when added to saturation.

The caseoses were separated from the fluid by saturation in the cold with ammonium sulphate, and from this precipitate, protocaseose was separated by solution in water and precipitation with sodium chloride. The sodium chloride precipitate was dissolved in water, the substance reprecipitated by saturation with salt, and again dissolved in water to which a trace of sodium carbonate was added to make the mixture quite neutral. On dialysis, a small amount of gummy heterocaseose separated, mixed with a little tyrosin. The clear fluid, now free from salts, was concentrated on a water-bath. As the evaporation advanced, a brown gummy mass settled out, which was, however, readily soluble in cold water, for as the concentrated fluid cooled at night the gummy matter entirely disappeared, reappearing as the fluid was again heated. The final concentrated fluid was treated with alcohol, the gummy precipitate boiled with alcohol repeatedly to free it from any adhering tyrosin, and finally extracted with ether and dried at 110° C.

Analyzed, it gave the following results :

Protocaseose, formed by sulphuric acid.

I. 0·4405 gram substance gave 0.2718 gram H_2O=6·85 per cent. H and 0·8756 gram CO_2=54·20 per cent. C.

II. 0·3783 gram substance gave 0·2341 gram H_2O=6·87 per cent. H and 0.7604 gram CO_2=54·81 per cent. C.

III. 0·3786 gram substance gave 48·3 c. c. N at 17·5° C. and 753·4 mm pressure=14·93 per cent. N.

IV. 0·3780 gram substance gave 47·8 c. c. N at 17·0° C. and 754·0 mm pressure=14·84 per cent. N.

V. 0·3701 gram substance gave 0·0113 gram ash=3·05 per cent.

VI. 0·5112 gram substance gave 0·0154 gram ash=3·02 per cent.

Percentage composition of ash-free substance.

					Average.
C	55·90	56·50		....	*56·20*
H	7·07	7·09	....	....	*7·08*
N	..	.	15·40	15·31	*15·36*

After being dried at 110° C. the substance dissolved with difficulty in water, leaving a large residue, but was readily and completely soluble in 0·2 per cent. hydrochloric acid and in 0·2 per cent. sodium carbonate. From the alkaline solution it was reprecipitated by hydrochloric acid, and not readily dissolved by an excess of the acid. Aqueous solution of the substance was rendered turbid by heat, the turbidity disappearing as the solution cooled. With dilute nitric acid, a white precipitate was formed, readily soluble on warming and reappearing as the solution cooled. Acetic acid and potassium ferrocyanide gave a heavy precipitate.

Thus in many respects this body resembles protocaseose formed by pepsin-hydrochloric acid, but is apparently characterized by a somewhat higher percentage of carbon.

The filtrate from the original sodium chloride precipitate, treated with salt-saturated 30 per cent. acetic acid, gave a flocculent, changing to gummy precipitate which was readily and completely soluble in water. The solution made exactly neutral was dialyzed without showing any evidence of a hetero-like body, finally concentrated and precipitated by alcohol. After being dried at 110° C., the substance was only partially soluble in water. The aqueous solution was rendered turbid by heat, clear again on cooling, and gave with nitric acid a heavy white precipitate as also with acetic acid and potassium ferrocyanide.

Analyzed, it gave the following results :

Acetic acid precipitate of caseose (a deuterocaseose?) formed by dilute sulphuric acid.

I. 0·4056 gram substance gave 0·2383 gram H_2O=6·52 per cent. H and 0·7733 gram CO_2=51·99 per cent. C.

II. 0·4697 gram substance gave 0·2740 gram H_2O=6·48 per cent. H and 0·8910 gram CO_2=51·73 per cent. C.

III. 0·5379 gram substance gave 66·5 c. c. N at 14·9° C. and 752·1 mm pressure=14·58 per cent. N.

IV. 0·4150 gram substance gave 0·0210 gram ash=5·06 per cent.

V. 0·5136 gram substance gave 0·0247 gram ash=4·80 per cent.

Percentage composition of ash-free substance.

				Average.
C	54·68	54·42	....	*54·55*
H	6·86	6·81	.	*6·84*
N	....	..	15·33	*15·33*

This caseose, instead of being a pure deutero body, appears to be a mixture of proto and *a* deutero as indicated by its behavior towards heat and nitric acid; indeed, the behavior of this acetic acid precipitate resembles the acetic acid precipitate of caseose obtained in our previous work, where the two bodies were plainly precipitated together. In composition, while it agrees closely with protocaseose formed by pepsin-hydrochloric acid, it has a higher content of carbon than the corresponding *a* deutero, but bears about the same relation to the sulphuric acid protocaseose as the *a* deutero formed by pepsin to its corresponding protocaseose.

On boiling the original ammonium sulphate-saturated filtrate, a second gummy precipitate gradually separated from the hot fluid. This caseose, after purification by the usual methods and drying at 110° C., was entirely soluble in hot and cold water, and was especially characterized by yielding with acetic acid a heavy white precipitate, soluble in excess of the acid. With nitric acid it also gave a white precipitate, soluble in excess of acid. Cupric sulphate likewise gave a heavy precipitate. The cold water solution was not rendered turbid by heat.

Analyzed it gave the following results:

β deuterocaseose, formed by dilute sulphuric acid.

I. 0·3952 gram substance gave 0·2308 gram H_2O=6·49 per cent. H and 0·7282 gram CO_2=50·25 per cent. C.

II. 0·3518 gram substance gave 0·2064 gram H_2O=6·51 per cent. H and 0·6440 gram CO_2=49·92 per cent. C.

III. 0·4727 gram substance gave 59·2 c. c. N at 15·0° C. and 754·9 mm pressure = 14·81 per cent. N.

IV. 0·4279 gram substance gave 0·0233 gram ash = 5·44 per cent.

V. 0·5184 gram substance gave 0·0219 gram ash = 5·38 per cent.

Percentage composition of ash-free substance.

				Average
C	53·10	52·77	....	*52·93*
H	6·86	6·89	..	*6·87*
N	...	....	15,66	*15·66*

Thus, this body, which corresponds to the *β* deuterocaseose formed by pepsin-acid, has a relatively higher content of carbon and also varies in certain of its reactions, which resemble rather those of *α* deutero, and even the protocaseose of a pepsin digestion, than those of a genuine *β* deutero.

Altogether, the three caseoses separated from the sulphuric acid solution of casein, while showing a certain general relationship to the caseoses formed by pepsin-hydrochloric acid, are sufficiently different in their individual reactions to suggest at least some difference in their nature.

d. Caseoses formed by the action of trypsin.

In subjecting casein to the action of trypsin, care was taken that the ferment solution should be as free as possible from all products of the self-digestion of the pancreatic tissue. Dried pancreas from the ox, prepared according to Kühne's method, was warmed with 0·1 per cent. salicylic acid at 40° C. for 24 hours, after which the acid extract was neutralized and made alkaline with sodium carbonate to the extent 0·3 per cent. The alkaline solution, well thymolized, was warmed at 40° C. for several days in order to convert the albuminous matters present into easily diffusible products, after which it was dialyzed in running water for some time, and the solution ultimately evaporated to dryness at 40° C. This residue, being extracted with a small volume of water, gives a fairly pure solution of trypsin, free from objectionable impurities.

In the formation of the caseoses, 2200 grams of pure, moist casein were soaked in 3 litres of 1 per cent. sodium carbonate for several days, and the mixture well thymolized to prevent putrefaction. The trypsin solution was then added, together with some water, and the whole warmed at 40° C. At first, the mixture was quite limpid, the casein being dissolved in the alkaline fluid, but after two or three days, gelatinous lumps began to appear on the bottom of the dish and finally a soft coagulum appeared on the surface and all through the mixture, resembling the separation of antialbumid. This coagulum gradually disappeared and at the end of five days the digestion was stopped, and the alkaline fluid filtered from the undigested residue. The latter was thoroughly washed with thymolized water and the washings added to the filtrate. This residue of undigested matter was found to be insoluble in 0·5 per cent. sodium carbonate and also in 0·2 per cent. hydrochloric acid, but on being warmed with pepsin-hydrochloric acid it was in time almost completely dissolved.

For separation of the caseoses the digestive fluid was neutralized with dilute hydrochloric acid, giving only a slight neutralization precipitate, and the neutral fluid concentrated. When moderately concentrated, the solution was placed in a cool place for several days to allow as much of the leucin and tyrosin to crystallize as possible. The caseoses were then separated from the filtrate, in the form of a gummy precipitate, by saturation of the fluid with ammonium sulphate. On boiling the filtrate from the first precipitate, and adding still more ammonium sulphate, a second gummy precipitate gradually settled out of the hot saturated fluid. This precipitate was separated from the fluid, the latter being saved for the detection of any peptone formed, washed with hot saturated ammonium sulphate solution, then dissolved in water and dialyzed until all traces of sulphate were removed. In the dialysis, no signs of any gummy heterocaseose or other like body was noticed. The caseose was precipitated from the suitably concentrated fluid with alcohol, boiled repeatedly with alcohol to free it from any adhering tyrosin, and finally dried at 110° C.

The substance was extremely soluble in water, the fluid remaining perfectly clear when heated. Acetic acid produced a heavy precipitate, soluble in excess, and in the acid fluid potassium ferrocyanide gave a heavy precipitate. Dilute nitric acid, added to the aqueous solution produced a white precipitate readily soluble in excess of acid, and when heated showed the xanthoprotein reaction.

Cupric sulphate also gave a heavy white precipitate. On analysis, the following results were obtained:

β deuterocaseose, formed by trypsin.

I. 0·3355 gram substance gave 0·1847 gram H_2O=6·11 per cent. H and 0·5990 gram CO_2=48·68 per cent. C.

II. 0·3459 gram substance gave 0·1871 gram H_2O=6·01 per cent. H and 0·6120 gram CO_2=48·24 per cent. C.

III. 0·5399 gram substance gave 63·0 c. c. N at 13·8° C. and 762·6 mm pressure = 13·63 per cent. N.

IV. 0·4166 gram substance gave by fusion with KOH + KNO_3 0·0300 gram $BaSO_4$=0·98 per cent. S; after deducting sulphur of ash = 0·95 per cent.

V. 0·5496 gram substance gave by fusion with KOH + KNO_3 0·0380 gram $BaSO_4$=0·95 per cent. S; after deducting sulphur of ash = 0·91 per cent.

VI. 0·4804 gram substance gave 0·0365 gram = 9·59 per cent.

VII. 0·4272 gram substance gave 0·0405 gram ash = 9·43 per cent.

VIII. Ash from 0·3076 gram substance gave 0·0181 gram $BaSO_4$ = 0·03 per cent. S.

Percentage composition of ash-free substance.

						Average.
C	53·81	53·81	....	....	....	*53·56*
H	6·76	6.64	....	....	....	*6·70*
N	...	....	15·07	....	...	*15·07*
S	...	...	....	0·95	0·91	*0·93*
O	...	...	....	....	..	*23·74*
						100·00

This sample of β deutero shows very close agreement in composition and reactions with the like body formed by dilute sulphuric acid; both being characterized by the reaction with acetic acid and showing, by their reactions and composition, a closer relationship to the proto-like bodies than their non-precipitation by ammonium sulphate would appear to warrant. In composition, however, this body shows a much smaller percentage of carbon than the caseose precipitated by acetic acid.

For separation of the other caseoses formed in this digestion, the first ammonium sulphate precipitate was dissolved in water and protocaseose precipitated by saturation of the solution with sodium chloride. The precipitate, which was not very heavy, was purified by reprecipitation and dialysis. On dissolving the first salt precipitate in water quite a little residue was noticed, soluble in dilute sodium carbonate, but readily precipitated by the least trace of acid. The final neutral solution was concentrated, giving when heated a heavy coagulum which finally came together as a gummy mass. The clear fluid, separated from the gum, gave still another coagulum as the heating was continued. On cooling, the gummy matter readily dissolved. As the evaporation continued and the fluid became concentrated the gummy matter dissolved even in the hot fluid, and the caseose was finally precipitated while hot with alcohol, and the precipitate boiled repeatedly with alcohol for the complete removal of leucin and tyrosin.

In reactions, this body was apparently identical with protocaseose formed by pepsin-hydrochloric acid, except that with acetic acid and also with hydrochloric acid it yielded a heavy white precipitate, soluble in excess of acid. In water it dissolved almost completely, the solution, however, becoming turbid when heated and if sufficiently

concentrated giving a gummy deposit as the heating continued. Further, the reaction with heat was the only respect in which this body differed from the preceding ammonium sulphate precipitate. Owing to insufficient quantity it was not analyzed.

In the filtrate from the first sodium chloride precipitate, a second caseose was precipitated by addition of a little 30 per cent. acetic acid. At first it separated as a flocculent precipitate, but on standing changed to a gummy mass, which dissolved more or less readily in water, and completely so when a little sodium carbonate was added to neutral reaction. After reprecipitation, the aqueous solution of the substance was neutralized, dialyzed, the solution concentrated without separation of any gummy matter, and the substance finally precipitated with alcohol The precipitate was boiled repeatedly with alcohol and finally dried at 110° C. The dried substance was readily soluble in water and also in dilute acetic acid, potassium ferrocyanide producing in the latter solution a slight turbidity only. Added to an aqueous solution of the substance, acetic acid produced a heavy white precipitate readily soluble in excess of the acid. Nitric acid, likewise, produced a heavy white precipitate not so readily soluble in excess. Cupric sulphate also gave a heavy white precipitate. The aqueous solution of the caseose gave no turbidity whatever, when heated.

Analyzed it yielded the following results :

Acetic acid precipitate of caseose (a deuterocaseose?) formed by trypsin.

I. 0·5594 gram substance gave 0·3300 gram H_2O=6·55 per cent. H and 1·0924 grams CO_2=53·25 per cent. C.

II. 0·3670 gram substance gave 0·2157 gram H_2O=6·53 per cent. H and 0·7158 gram CO_2=53·19 per cent. C.

III. 0·3811 gram substance gave 44·4 c. c. N at 12·8° C. and 765·1 mm pressure =14·07 per cent. N.

IV. 0·2848 gram substance gave 33·0 c. c. N at 13·4° C. and 765·5 mm pressure =13·98 per cent. N.

V. 0·4351 gram substance gave 0·0230 gram ash =5·28 per cent.

VI. 0·4033 gram substance gave 0·0210 gram ash =5·26 per cent.

Percentage composition of ash-free substance.

					Average
C	56·20	56·14	....	....	*56·17*
H	6·91	6·89	....	....	*6·90*
N	....	....	14·85	14·75	*14·80*

It is thus obvious from the foregoing that by the action of trypsin, caseoses are formed of the same general nature as those formed by the action of pepsin-hydrochloric acid, and by hot dilute sulphuric acid, but with higher contents of carbon.

In other digestions with trypsin, made especially for the preparation of casein peptone, these caseoses were again separated and the foregoing reactions verified. The quantities, however, were too small to admit of their analysis.

III. *Casein peptone*;—from experiments by *Charles Norris, Jr., Ph.B.*

Supersaturation of a digestive fluid with ammonium sulphate, under proper conditions, suffices to entirely remove the preliminary products of proteolytic action. Proper conditions, however, are not obtained by simply adding the ammonium salt to a cold fluid, for as has been already pointed out an additional precipitate of proteose can nearly always be obtained, by heating the cold saturated solution until a thick crust of the ammonium salt forms on the hot fluid. In the present state of knowledge, we assume as peptone any amorphous product of proteolytic action precipitable by alcohol, and not precipitable by heating with ammonium sulphate added to saturation. Unquestionably, the albumose precipitated only by long boiling of a saturated ammonium sulphate solution, is much nearer to true peptone than those bodies more easily precipitated, but at present we are not inclined to accept as true peptone any body precipitable by ammonium sulphate under any conditions whatever. In the present series of experiments we have aimed to prepare a casein peptone, by the action of trypsin, entirely free from albumose in order to study its composition and reactions.

In the digestion of casein with trypsin, described in the preceding section, the filtrate from the ammonium sulphate saturation was heated for some time and the slight gummy film of caseose separated, after which as much of the ammonium sulphate as possible was removed by alternate crystallization, treatment with alcohol, etc. The last traces of the ammonium salt were removed by long continued dialysis in running water, and when finally the fluid gave no reaction with barium chloride it was evaporated to a syrup and precipitated with alcohol. The precipitated peptone was freed from any adhering tyrosin and leucin by repeated treatment with boiling alcohol, and finally dried at 110° C. until of constant weight. This proved a long operation. The peptone was so exceedingly hygroscopic and held on so tenaciously to the water, that it was only after

long-continued drying that a constant weight was reached and then the odor was strongly suggestive of partial dissociation. In a previous article* on peptone, attention was called to the peculiar odor of valerianic acid almost invariably noticed when the fibrin peptone was dried at 110° C., but in that case it was found impossible to bring the product to a constant weight. With casein peptone, the same odor was noticeable on drying the product for analysis, but after a few days heating at 110° C., the weight of the product remained fairly constant.

On analysis, the casein peptone yielded the following results:

Casein antipeptone A.

I. 0·5792 gram substance gave 0·3185 gram H_2O=6·11 per cent. H and 0·9951 gram CO_2=46·85 per cent. C.

II. 0·4692 gram substance gave 0·2562 gram H_2O=6·07 per cent. H and 0·8060 gram CO_2=46·84 per cent C.

III. 0·4357 gram substance gave 55·5 c. c. N at 14·0° C. and 762·0 mm pressure=15·27 per cent. N.

IV. 0·6534 gram substance gave 83·0 c. c. N at 14·0° C. and 761·0 mm pressure=15·18 per cent. N.

V. 0·9703 gram substance gave 0·0656 gram ash=6·76 per cent.

VI. 0·4939 gram substance gave 0·0326 gram ash=6·60 per cent.

VII. 0·7032 gram substance gave by fusion with KOH+KNO_3 0·0386 gram $BaSO_4$=0·75 per cent. S.

VIII. 0·6526 gram substance gave by fusion with KOH+KNO_3 0·0337 gram $BaSO_4$=0·71 per cent. S.†

Percentage composition of ash-free substance.

							Average.
C	49·94	49·93	....	....	.	...	*49·94*
H	6·51	6·50	....	....	..	....	*6·51*
N		..	16·35	16·26	..	.	*16·30*
S	....	....	...	...	0·70	0·66	*0·68*
O	....	...	....	....	.	...	*26·57*
							100·00

Somewhat to our surprise, on testing the purified and dried peptone, we found that its aqueous solution gave a heavy white precipitate with nitric acid, soluble in excess of acid; likewise, a heavy precipitate with acetic acid, also soluble in excess; with cupric sul-

* Kühne and Chittenden, Peptone Studies, vol. ii

† The ash contained only a slight unweighable trace of sulphate

phate a heavy precipitate; and on saturation with ammonium sulphate in the cold an abundant gummy precipitate, the latter plainly indicating the presence of caseose. As the product originally gave no precipitate with ammonium sulphate, it would apparently follow that the peptone by long drying at 110° C. had been, in part, reconverted into caseose, and as the solution gave no turbidity by heat it would imply that the caseose formed by the reconversion of the peptone was the deutero body. Results similar to these were obtained by Kühne and Chittenden with fibrin peptone.

In a second digestion of trypsin, 1 kilo. of moist casein was warmed at 40° C. with 4 litres of 0·6 per cent. sodium carbonate solution containing trypsin, well thymolized, for one week. On the third day, the gelatinous coagulum already described made its appearance, but gradually disappeared and at the end of the week there was only a very small residue remaining. The neutralized and concentrated digestive fluid, freed from more or less tyrosin by cooling and crystallization, was in this case treated with rock salt to saturation, yielding, however, only a small precipitate of proto- and heterocaseose, which on purification agreed in reactions with the caseoses previously described. Addition of salt-saturated acetic acid to the sodium chloride filtrate from the foregoing caseoses, failed to give any precipitate whatever, and as the saturation of the fluid with ammonium sulphate gave only a slight gummy precipitate it is evident that in this digestion the casein was almost completely converted into peptone. In order to be quite sure of the complete removal of everything precipitable by the ammonium salt the mixture was boiled for some time with an excess of ammonium sulphate, and the filtrate treated as described under peptone *A* for the complete removal of tyrosin and ammonium sulphate.

The final product was exceedingly gummy and parted with the last traces of adhering alcohol very slowly. In fact, we found it best to dissolve the final alcoholic precipitate of peptone in a little water, and to drive off the alcohol from the solution by heat, after which the fluid was evaporated and the gummy peptone finally transformed into a friable mass by drying on a water-bath, and at last completely dried at 110° C. After its final precipitation with alcohol, an aqueous solution of the peptone gave no precipitate whatever, with nitric or acetic acid, neither with acetic acid and potassium ferrocyanide nor with cupric sulphate, or at the most nothing more than a faint turbidity. After being dried at 110° C. until of constant weight, the product then gave a decided gummy precipitate by saturation

of its aqueous solution with ammonium sulphate, and like peptone *A* gave precipitates with nitric and acetic acid and with cupric sulphate.

On analysis the following results were obtained:

Casein antipeptone B.

I. 0·3770 gram substance gave 0·2023 gram H_2O=5·96 per cent. H and 0·6535 gram CO_2=47·25 per cent. C.

II. 0·2687 gram substance gave 0·1442 gram H_2O=5·96 per cent. H and 0·4667 gram CO_2=47·36 per cent. C.

III. 0·3732 gram substance gave 44·9 c. c. N at 14·4° C. and 757·0 mm pressure=14·31 per cent. N.

IV. 0·3801 gram substance gave 46·0 c. c. N at 14·0° C. and 756·0 mm pressure=14·38 per cent. N.

V. 0·4760 gram substance gave 0·0374 gram ash=7·86 per cent.

VI. 0·5396 gram substance gave 0·0429 gram ash=7·95 per cent.

Percentage composition of ash-free substance.

					Average.
C	51·35	51·42	...	..	*51·38*
H	6·47	6·47	....	....	*6·47*
N	.		15·54	15·61	*15·57*

In a third digestion with trypsin, 2 kilos. of casein were warmed at 40° C. for five days with 3 litres of 0·5 per cent. sodium carbonate containing an active trypsin solution, well thymolized. At the end of the second day, considerable casein antialbumid separated from the solution, this time more as a gummy precipitate than as a gelatinous coagulum. On the sixth day, the alkaline fluid was filtered from the small undigested residue, neutralized, concentrated, and the caseoses precipitated by saturation with ammonium sulphate. In this digestion, there was present only a very small trace of caseose precipitable by saturation with salt, but considerable precipitable by salt-saturated acetic acid. After repeated boiling of the ammonium sulphate-saturated fluid, for complete removal of caseoses, the peptone remaining was separated, purified and dried as already described. The product dried at 110° C. gave on analysis the following results.

Casein antipeptone C.

I. 0·3104 gram substance gave 0·1720 gram H_2O=6·15 per cent. H and 0·5252 gram CO_2=46·14 per cent. C.

II. 0·2756 gram substance gave 0·1513 gram H_2O=6·10 per cent. H and 0·4638 gram CO_2=45·89 per cent. C.

III. 0·5432 gram substance gave 68·0 c. c. N at 14·6° C. and 756·4 mm pressure=14·88 per cent. N.

IV. 0·6280 gram substance gave 0·0449 gram ash=7·15 per cent.

V. 0·4060 gram substance gave 0·0288 gram ash=7·09 per cent.

Percentage composition of ash-free substance.

				Average
C	49·64	49·40	..	49·52
H	6·63	6·57	....	6·60
N		....	15·99	15·99

This peptone, like the preceding, after being dried at 110° C. gave a small gummy precipitate on saturation of its solution with ammonium sulphate, and also gave a precipitate with nitric and acetic acid, and a slight turbidity with cupric sulphate.

In composition, all three of the peptones show a smaller percentage of carbon than the caseoses formed by trypsin, but somewhat to our surprise the percentage of carbon is higher than in some of the caseoses formed by pepsin-hydrochloric acid. The nature of the substance, however, which at present affords but little proof that we have to deal with a single body, the extreme difficulty of obtaining it in a condition of dryness suitable for analysis, and the almost utter impossibility of freeing it from adhering inorganic salts, all tend to throw doubt on the analytical data as expressing the composition of pure casein peptone. As already stated, there is unquestionably more or less of a decomposition or change attending the drying of the peptone. So pronounced is the hygroscopic character of these bodies, that when partially dried they will gain weight over strong sulphuric acid, and on being taken from the air bath while drying at 110° C. we often noticed on damp days a hissing noise as if from the rapid absorption of water. Further, as the drying progressed the odor of valerianic acid became quite pronounced and on testing the dried product, it was often found to have an acid reaction so pronounced in many cases as to give a sour taste to the peptone, in addition to the characteristic bitter. Before drying, the peptones were usually found to have a neutral reaction. These facts coupled with the changed behavior of the product towards ammonium sulphate, point to a change in the nature of the peptone, which may well be assumed to affect its composition, and hence we would have our analytical figures taken with some allowance.

We also prepared a peptone, entirely non-precipitable by saturation with ammonium sulphate, by boiling 20 grams of pure deuterocaseose with 500 c. c. of 3 per cent. sulphuric acid for 14 hours. This preparation, after purification, was too small in quantity for analysis, but in reactions it showed close agreement with the antipeptones prior to their long drying at 110° C., viz: non-precipitation by acetic acid and potassium ferrocyanide, by nitric acid, by cupric sulphate, and by saturation with ammonium sulphate both in neutral and in acid solutions.

VI.—Some Experiments on the Influence of Arsenic and Antimony on Glycogenic Function and Fatty Degeneration of the Liver. By R. H. Chittenden, and J. A. Blake, B.A., Ph.B.

Saikowsky's* oft-quoted experiments on rabbits with antimonic and arsenious acids have made clear that in both arsenical and antimonial poisoning there is pronounced fatty degeneration of the liver, with a lessening of the hepatic glycogen and in some cases even a total disappearance of it. With antimonic acid, Saikowsky found in his original experiments, that one-half to one gram of antimonic acid or other preparation of antimony per day, for fourteen or nineteen days in succession, gave rise to a fatty degeneration embracing the liver, kidneys, and even the heart. This has been verified by the experiments of Grohe and Mosler, who also state that in the duchy of Brunswick the peasantry give to the geese, when producing the famous fatty livers, a certain quantity of the white oxide of antimony every day.† With arsenic, Saikowsky likewise found that when rabbits are poisoned by a small dose so as to live from three to six days, the liver becomes much enlarged and very fatty and the glycogenic function nearly or quite abolished.

It is very evident, therefore, that in large quantities both arsenic and antimony have a special action on tissue changes, particularly on the liver. In the experiments referred to above, the quantities of poison given were quite large and with arsenic, particularly, their administration was soon followed by death. As neither of these substances are ordinarily used in medicine for an acute effect, it seemed to us of interest to study the action of small doses on the tissue changes of the liver, with a view to ascertaining whether non-toxic doses of these two poisons would produce a similar effect. It is ordinarily stated that in poisoning with antimony, phosphorus, and arsenic the nitrogenous products of tissue waste appear in the urine in much larger quantity than normally, owing to the increased decomposition which is going on.‡ Experiments of our own, however, have shown that

* Virchow's Archives, Band xxxiv, p. 78.

† Quoted from H. C. Wood's Therapeutics, p. 161.

‡ Brunton's Pharmacology, Therapeutics and Materia Medica, p. 360.

small repeated doses of antimonious oxide are without influence on the excretion of nitrogen, sulphur, and phosphorus, and that hence when taken in non-toxic doses it has no noticeable action on proteid metabolism.* Without doubt, toxic doses do materially affect the nutrition of the body, but with a dog of 13 kilos. weight the administration of repeated doses of antimonious oxide, to the extent of 17 grains in 13 days, led to no apparent change in the amount of nitrogen etc. excreted, although the presence in the 24 hours' urine of 13–23 milligrams of antimony (Sb) gave evidence of decided absorption.

We have therefore tried a few experiments on rabbits and fowls to see what effect small repeated doses of arsenic and antimony would have on the liver, as indicated by its content of fat, glycogen, and sugar. The experiments were made in pairs, in which one animal of each pair served as a control for comparison, while the other, kept under the same conditions of diet, etc. so far as possible, was fed each day with arsenic or antimony as the case might be. At the end of the period both animals were killed and the livers analyzed. Naturally, the animals of each pair were of the same age, from the same brood, and so far as possible of the same body weight. During the experiment they were kept on a weighed diet of cracked corn, meal, etc., and were confined in suitable cages.

The methods of analysis were as follows: after determining the body weight, the liver was quickly removed, weighed and sampled by chopping, 10 grams or thereabouts were then weighed out accurately, dried on a water bath, ground to a fine powder and extracted in a fat extractor with warm ether until the fat was entirely removed.

For glycogen and sugar, 20–40 grams of the sampled liver were thoroughly extracted with hot water, (continuous extraction with water, frequently renewed, for several days) the extracts united, concentrated to a very small volume and precipitated with a large excess of 95 per cent. alcohol. The precipitate of glycogen, etc., was washed with alcohol, dissolved in a small volume of cold water to 100 c. c., sufficient hydrochloric acid added to make the fluid contain 2 per cent. HCl and heated on a water-bath for 15 hours. After neutralization, the volume was made up to 200 c. c. and the sugar determined in 25 c. c. of the fluid by Allihn's gravimetric method, and the glycogen calculated therefrom. The liver sugar was determined by evaporating the alcoholic fluid from the glycogen precipitate, dissolving the residue in a little water, adding sufficient sulphuric acid to make the mix-

* Chittenden and Blake. Studies from Laboratory of Physiological Chemistry, Yale University, vol. ii, p. 94.

ture contain 2 per cent. H_2SO_4, boiling for two hours to convert the sugar wholly into dextrose, and then, after neutralization of the acid fluid and diluting to 200 c. c., testing its reducing power by Allihn's method.

Experiment I.

Action of arsenic on a fowl.

Period of dosing.

May 20–24,	0 1 grain As_2O_3 daily
" 25–31,	0 2 " " "
June 1–15,	0 3 " " "
	6 4 grains.

	A, control fowl	*B, arsenic fowl.*
Body weight May 20,	1814 grams	1814 grams
" " June 16,	1871 "	1686 "
	+57	-128
Weight of liver, June 16,	28 378 grams	34 635 grams

The liver of B, showed unmistakeable signs of fatty degeneration

Determination of fat in liver.

A control,	9 210 grams liver gave	0 3347 gram fat,	=	3·63 per cent.
B arsenic,	13 848 " " "	1 8561 " "	=	13 40 "
				+ 9·77 per cent.

Determination of glycogen and sugar.

	A.	*B.*
Weight of liver used,	20 167 grams	20·787 grams.

Glycogen A, control

Volume used	Weight Cu	Equivalent in dextrose	Equivalent in glycogen	Total amount	Per cent.
25 c. c	0 0744 gram	0 0380 gram	0·0342 gram	0 2736 gram.	1 35
25	0 0727	0·0371	0·0334	0 2672	1·32

Glycogen B, arsenic.

Volume used	Weight Cu	Equivalent in dextrose	Equivalent in glycogen	Total amount	Per cent.
25 c c	0 1720 gram	0 0879 gram	0 0791 gram.	0·6328 gram	3 04
25	0·1713	0·0875	0·0787	0 6296	3 02

Sugar A, control.

Volume used	Weight Cu	Equivalent in dextrose	Equivalent in glycogen	Total amount	Per cent.
25 c. c.	0 0299 gram.	0·0159 gram.	....	0 1272 gram	0 63
25	0·0332	0 0176	..	0·1408	0·69

Sugar B, arsenic.

Volume used	Weight Cu	Equivalent in dextrose	Equivalent in glycogen	Total amount	Per cent.
25 c. c.	0·0185 gram.	0·0102 gram.	.....	0·0816 gram.	0·39
25	0·0162	0·0091	....	0 0728	0·35

100 grams of breast muscle from *B* gave 0 4 milligram of *As*.

In this experiment, then, we have as the apparent result of the long-continued feeding of arsenic a loss of body weight, a decided increase

in the weight of the liver, a large increase in the liver fat, a gain in the amount of liver glycogen, and a loss in liver sugar.

Experiment II.

Action of arsenic on a fowl.

Period of dosing.

May 20–24,	0·1 grain As_2O_3 daily.
" 25–31,	0·2 " " "
June 1–15,	0·3 " " "
" 16–18,	0·4 " " "
	7·6 grains.

Towards the end of the experiment the arsenic fowl appeared to be suffering somewhat from the toxic action of the poison, consequently the arsenic was discontinued after the 18th, but the fowl died on the 21st, and was immediately analyzed.

	A, control fowl.	*B, arsenic fowl.*
Body weight May 20,	1644 grams.	1531 grams.
" " June 21,	1757 "	1247 "
	+113	−284
Weight of liver, June 21,	55·830 grams.	33·729 grams.

Determination of fat in liver.

A, control,	13·740 grams liver gave 0·7462 gram fat,	=	5·40 per cent.
B, arsenic,	10·179 " " " 0·4925 " "	=	4·83 "
			−0·57 per cent.

Determination of glycogen and sugar.

	A.	*B.*
Weight of liver used,	42·090 grams.	23·550 grams.

Glycogen A, control.

Volume used.	Weight Cu.	Equivalent in dextrose.	Equivalent in glycogen.	Total amount.	Per cent.
25 c. c.	0·5213 gram.	0·2500 gram.	0·2250 gram.	1·8000 gram.	4·27
25	0·5238	0·2504	0·2253	1·8024	4·28

Sugar A, control.

25 c. c.	0·0359 gram.	0·0188 gram.	.....	0·1504 gram.	0·35
25	0·0379	0·0198	.....	0·1584	0·37

In *B*, no trace of a reduction could be obtained for glycogen and only an unweighable trace for sugar.

In this experiment, therefore, we find a decided loss in body weight under the influence of the arsenic, a loss in the weight of the liver, a slight diminution in the liver fat and nearly a complete disappearance of both glycogen and sugar.

Experiment III.

Action of arsenic on a rabbit.

Period of dosing.

May 25–31,	0·2 grain As_2O_3 daily.
June 1–15,	0·3 " " "
" 16–23,	0·4 " " "
	9·1 grains.

	A, control rabbit.	*B, arsenic rabbit.*
Body weight May 25,	1644 grams.	1502 grams.
" " June 24,	1616 "	1586 "
	—28	+ 84
Weight of liver June 24,	61·360 grams.	46·760 grams.

Determination of fat in liver.

A, control,	15·320 grams liver gave 0·4126 gram fat,	=	2·69 per cent.
B, arsenic,	14·435 " " " 0·2888 " "	=	2·00 "
			—0·69 per cent.

Determination of glycogen and sugar.

	A.	*B.*
Weight of liver used,	45·940 grams.	32·325 grams.

Volume used for reduction.	Weight Cu.	Equivalent in dextrose.	Equivalent in glycogen.	Total amount.	Per cent.
		Glycogen A, control.*			
25 c. c.	0·2036 gram.	0·1045 gram.	0·0940 gram.	1·8800 grams.	4·13
25	0·2027	0·1041	0·0937	1·8740	4·07
		Glycogen B, arsenic.			
25 c. c.	0·5230 gram.	0·2503 gram.	0·2252 gram.	1·8016 grams.	5·57
25	0·5223	0·2500	0·2250	1·8000	5·54
		Sugar A, control.			
25 c. c.	0·0177 gram.	0·0098 gram.	.....	0·0784 gram.	0·17
25	0·0173	0·0097	.....	0·0776	0·16
		Sugar B, arsenic.			
25 c. c.	0·0254 gram.	0·0137 gram.	.....	0·1096 gram.	0·34
25	0·0232	0·0126	.....	0·1008	0·31

100 grams of muscle tissue yielded 0·3 milligram of *As*.

Here, we find under the influence of the arsenic, an apparent gain, though slight, in body weight, an evident diminution in the weight of the liver, together with a diminished percentage of liver fat. Apparently, however, the amount of liver glycogen and sugar are somewhat increased. The liver showed no approach to fatty degeneration on microscopic examination.

* The glycogen solution after boiling with acid, etc., was made up to 500 c. c. instead of 200 c. c.

Experiment IV.

Action of antimony on a fowl.

Period of dosing.

May 20–24,	0·2 grain Sb_2O_3 daily.
" 25–31,	0·4 " " "
June 1–7,	0·6 " " "
" 8–14,	0·8 " " "
	13·6 grains.

	A, control fowl.	*B, antimony fowl.*
Body weight May 20,	1559 grams,	1616 grams,
" " June 15,	1531 "	1828 "
	—28	+212
Weight of liver June 15,	22·995 grams.	31·799 grams

Determination of fat in liver.

A, control,	7·985 grams liver gave 0·4600 gram fat,	= 5 76 per cent
B, antimony,	11 409 " " " 0 6741 " "	= 5·91 "
		+0 15 per cent

Determination of glycogen and Sugar.

	A.	*B.*
Weight of liver used,	15·010 grams	20·390 grams.

Glycogen A, control.

Volume used for reduction	Weight Cu	Equivalent in dextrose	Equivalent in glycogen.	Total amount.	Per cent
25 c c.	0·0577 gram.	0·0296 gram.	0·0266 gram.	0·2128 gram.	1 41
25	0·0563	0·0289	0·0260	0·2080	1·38
		Glycogen B, antimony			
25 c. c.	0·1011 gram	0·0514 gram.	0·0462 gram.	0·3696 gram	1·81
25	0·1015	0·0516	0·0464	0·3712	1 82
		Sugar A, control.			
25 c. c.	0·0198 gram.	0·0109 gram.	.....	0·0872 gram	0·58
25	0·0211	0·0115	.....	0·0920	0·61
		Sugar B, antimony.			
25 c. c.	0·0800 gram.	0 0160 gram.	.....	0·1280 gram.	0·62
25	0·0277	0·0148	.....	0·1184	0·58

100 grams of breast muscle gave 1·2 milligrams Sb.

These results would seem to indicate that antimonious oxide tends to increase the body weight, and apparently also that of the liver. The liver fat is obviously not much affected in this experiment, while the glycogen shows a slight increase in the antimonial fowl.

Experiment V.

Action of antimony on a fowl.

Period of dosing.

May 20–24,	0·2 grain Sb_2O_3 daily.
" 25–31,	0·4 " " "
June 1– 7,	0·6 " " "
" 8–15,	0·8 " " "
" 16–19,	1·0 " " "
	18·4 grains.

	A, control fowl.	*B, antimony fowl.*
Body weight May 20,	1701 grams.	1757 grams.
" " June 20,	1644 "	1814 "
	—57	+57
Weight of liver June 20,	34·177 grams.	35·440 grams

Determination of fat in liver.

A, control,	9·477 grams liver gave	0·3890 gram fat,	= 4·10 per cent
B, antimony,	9·579 " " "	0·5088 " "	= 5·31 "
			+ 1·21 per cent.

The appearance of the liver in *B* indicated fatty degeneration.

Determination of glycogen and sugar

	A.	*B.*
Weight of liver used,	24·700 grams.	25·871 grams.

Glycogen A, control.

Volume used for reduction.	Weight Cu.	Equivalent in dextrose.	Equivalent in glycogen.	Total amount.	Per cent.
25 c. c.	0·2253 gram.	0·1160 gram.	0·1044 gram.	0·8352 gram.	3·38
25	0·2253	0·1160	0·1044	0·8352	3·38

Glycogen B, antimony.

25 c. c.	0·2480 gram.	0·1281 gram.	0·1153 gram.	0·9224 gram.	3·56
25	0·2479	0·1280	0·1150	0·9200	3·55

Sugar A, control.

25 c. c.	0·0360 gram.	0·0189 gram.	-----	0·1512 gram.	0·61
25	0·0360	0·0189	-----	0·1512	0·61

Sugar B, antimony.

25 c. c.	0·0383 gram.	0·0200 gram.	-----	0·1600 gram.	0·62
25	0·0372	0·0195	-----	0·1560	0·60

100 grams of breast muscle gave 1·3 milligrams Sb.

In this experiment, there was pronounced fatty degeneration of the liver in the antimonial fowl. Further, as in the last experiment, there was apparently a slight increase both in body weight and in the weight of the liver.

Corresponding with the fatty degeneration, there was found 1·2 per cent. more fat in the antimonial liver than in the control.

The liver glycogen was also slightly increased under the influence of the antimony.

Experiment VI.

Action of antimony on a rabbit.

Period of dosing.

May 25–31,	0·4 grain Sb_2O_3 daily
June 1– 7,	0·6 " " "
" 8–15,	0·8 " " "
" 16–21,	1·0 " " "
	19·4 grains

	A, control rabbit	*B*,* antimony rabbit
Body weight May 25,	2012 grams.	1814 grams
" " June 23,	1998 "	1701 "
	—14	—113
Weight of liver June 23,	38·219 grams	42·741 grams

Determination of fat in liver.

A, control,	9·375 grams liver gave 0·3575 gram fat,	=	3·81 per cent
B, antimony,	10·971 " " " 0·3432 " "	=	3·12 "
			—0·69 per cent

Determination of glycogen and sugar.

	A.	*B*
Weight of liver used,	28·844 grams.	31·770 grams

Glycogen A, control

Volume used for reduction	Weight Cu.	Equivalent in dextrose.	Equivalent in glycogen	Total amount	Per cent
25 c. c.	0·0431 gram	0·0224 gram	0·0201 gram	0·1608 gram.	0·55
25	0·0441	0·0229	0·0206	0·1648	0·57

Sugar A, control

25 c. c.	0·0445 gram.	0·0231 gram	.....	0·1848 gram	0·64
25	0·0440	0·0229	.....	0·1832	0·63

In *B*, there was no reduction for either glycogen or sugar.

100 grams of muscle gave 1·0 milligram Sb.

In this experiment, towards the end, the animal was evidently suffering from the toxic action of the antimony, and the body weight is seen to be noticeably diminished. The weight of the liver, however, was apparently increased by the antimony, although there was a

* The last two days the antimony rabbit ate very little. Hence, the oxide was not given after the 21st. The animal was evidently much affected by the antimony and its general nutrition was at the last very poor.

diminution in the liver fat, and a complete disappearance of both glycogen and sugar.

While these experiments are far too few in number to generalize from, yet it would appear that small doses of antimonious oxide long continued tend to increase body weight, and particularly the weight of the liver. Further, the increase in liver weight is accompanied by an increased percentage of fat and a slight increase of liver glycogen.

With corresponding doses of arsenious oxide, on the other hand, the results would indicate a diminution in body weight, likewise a diminution in the weight of the liver and also in the amount of liver fat. As regards glycogen, two of the results show an increased amount in the arsenical livers, while in one experiment there was a total disappearance of glycogen. On the other hand, as Experiment No. I indicates, there may be, with small doses of arsenic, a very pronounced fatty degeneration of the liver, accompanied by an increased liver weight and an increase in the percentage of liver glycogen.

VII.—The Nature and Chemical Composition of the Myosin of Muscle Tissue. By R. H. Chittenden and G. Wyckoff Cummins, Ph.D.

In spite of the interest attached to this peculiar proteid substance, little attention has been directed to its chemical nature since the time of its discovery by Kühne.* In fact, Danilewsky† is the only investigator who appears to have studied its chemical relations to any extent, and so far as we are aware no attempt has ever been made to ascertain its chemical composition. With this fact in mind, it has been the main object of the present investigation to study the chemical composition of pure myosin, and to determine the differences that may exist in the chemical nature, or in the properties, of myosin prepared from various animal sources. Unfortunately, our work was completed before Halliburton's‡ recent paper on muscle-plasma was published, otherwise we should have attempted to verify some of his interesting discoveries regarding the muscle clot, and possibly have modified somewhat the character of our work.

The researches of Kühne, Hoppe-Seyler,§ Weyl,‖ and Danilewsky have shown that myosin, both from the animal and vegetable kingdoms, is a globulin body, soluble in dilute sodium and ammonium chloride solutions, as well as in sulphate of magnesia and sulphates of the alkalies, and precipitable therefrom either by the addition of salt in substance or by dilution with much water. As stated by Danilewsky, myosin is most advantageously extracted from muscle tissue by ammonium chloride, in solutions of from 7-20 per cent. We have, likewise, found this to be the case by comparative tests, and have, therefore, in all of our preparations of myosin for analysis. used ammonium chloride as the extractive, preferably of 15 per cent. strength. For separation of myosin from the ammonium chloride

* Kühne, Protoplasma, Leipzig, 1864. Also Lehrbuch der physiologische Chemie.

† Myosin, seine Darstellung, Eigenschaften, Umwandlung in Syntonin und Rückbildung aus demselben. Zeitschrift fur physiologische chemie. Band v, p 158.

‡ Journal of Physiology, vol. viii, p. 133.

§ Handbuch der Chem. Analyse, 4 Auflage, p. 236.

‖ Beitrage zur kenntniss thierischer und pflanzlicher eiweisskorper, Zeitschrift fur physiologische Chemie, Band i, p. 72.

solution we have mainly employed two methods, either dilution with a large volume of distilled water, or dialysis of the ammonium chloride solution until the salt is entirely removed. In this latter process, we have often observed that the separation of myosin partakes more of the nature of a coagulation than of an ordinary precipitation. A moderately strong ammonium chloride solution of myosin, on being placed in a parchment bag and suspended in running water, will ordinarily at the end of two or three days be converted into a semi-solid, jelly-like mass, which later on contracts more or less, but still shows all the characters of a genuine clot. In fact, we are inclined, with Halliburton, to consider this a genuine re-coagulation rather than a precipitation. We are inclined, however, to believe that separation of myosin by dialysis is hardly as satisfactory in the preparation of small quantities, as precipitation by water, since on dialysis the jellying of the myosin naturally tends to enclose some of the salt and also any other proteids possibly present in the solution, while by precipitation with water the myosin is flocculent, easily washed and thus more surely freed from both salt and albumin.

Myosin A, from ox muscle.

The first sample of myosin was prepared from a freshly killed ox. The finely chopped muscle from the thigh was freed, so far as possible, from all traces of blood and soluble albumin by long soaking and frequent kneading with water. The water was frequently changed and kept thoroughly thymolized so as to prevent any approach to putrefaction. When the washings failed to give any turbidity by heat, or by acetic acid and potassium ferrocyanide, the washed tissue was placed in 10 litres of a 15 per cent. solution of ammonium chloride for extraction of the myosin. The resultant opalescent fluid was filtered through paper and the myosin precipitated by saturation with sodium chloride. The precipitate was quickly strained off, dried somewhat between folds of filter paper, dissolved in a small amount of water and reprecipitated by treatment of the fluid with a large volume of water. The precipitate so obtained was washed with water until the washings gave no reaction for chlorides, when it was treated with weak alcohol and finally with 95 per cent. and absolute alcohol, and ether.

When partially dried, it was ground fine and further dried at 110° C. until of constant weight, for analysis.

Its composition is shown in the accompanying table.

ANALYSIS OF MYOSIN A, FROM OX MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T. °C.	N found. Pressure mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ from the Ash. gram.	S of Ash. % of sub	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of Ash %
I	0·3878	0·2442	6·99	0·7400	52·04	---	---	-----	---	---	---	----	---	----	---	-----
II	0·5659	0·3579	7·03	1·0809	52·09	---	---	-----	---	----	---	----	---	----	---	-----
III	0·5996	------	---	------	----	81·7	8·7	758·4	16·61	----	---	--	---	----	---	-----
IV	0·5783	------	---	------	----	80·1	10·0	757·7	16·69	----	---	----	---	---	---	-----
V	0·6794	------	---	------	----	---	---	------	---	0·0101	1·49	---	---	----	---	-----
VI	0·8173	------	---	------	----	---	---	------	---	0·0121	1·48	---	---	----	---	----
VII	1·4967	------	---	------	----	---	---	----	---	----	---	0·0064	0·05	----	---	-----
VIII	0·6930	------	---	-----	----	---	---	------	---	----	--	----	---	0·0799	1·58	1·53
IX	0·9133	-----	---	------	--	---	--	-----	---	----	---	----	---	0·0965	1·44	1·39

Percentage composition of the ash-free substance.

							Average.
C	52·83	52·84	----	----	----	----	*52·84*
H	7·10	7·13	----	----	----	----	*7·12*
N	--	-	16·84	16·94	----	----	*16·89*
S	-	----	----	----	1·56	1·42	*1·49*
O		----	----	----	----	-	*21·66*
							100·00

Myosin B, from ox muscle.

A solution of myosin in 15 per cent ammonium chloride was prepared from 4 kilos. of freshly killed beef, as described under A. The myosin was then separated from the solution by dialysis, continued until nearly all of the chloride was removed. The last traces of the ammonium salt were separated by filtration of the gelatinous myosin through chamois skin, and washing with water. The preparation was then treated exactly as A, and dried at 110° C. for analysis.

By long continued contact with water, as in dialysis, the precipitated or coagulated myosin is rendered insoluble in dilute salt solutions, as noticed by Weyl and others, hence in this preparation it was not possible to purify the substance by reprecipitation.

The composition of the product (see the accompanying table) is essentially the same as that of the preceding preparation.

Myosin C, from sheep's muscle.

This sample of myosin was obtained from fresh mutton in essentially the same manner as the preceding preparation, viz: by extraction of the thoroughly washed tissue with 15 per cent. ammonium chloride, and separation of the myosin by dialysis.

On analysis, it was found to possess a somewhat higher percentage of carbon than the two myosins from ox muscle, but in other respects it was identical with them.

Myosin D, from calf's muscle.

A solution of myosin was prepared from 3 kilos. of fresh, lean muscle from a young calf, by extraction of the thoroughly washed tissue with 15 per cent. ammonium chloride solution.

From one-half of the filtered fluid, myosin was precipitated by dilution with water and purified by washing with water until chlorides were entirely removed. It was then washed with weak alcohol, finally with absolute alcohol and ether, and then dried at 110° C. for analysis (D^1).

From the other half of the ammonium chloride solution, myosin was separated by addition of ammonium chloride in substance. The precipitate was freed from excess of ammonium chloride by addition of just enough water to dissolve the salt, after which the flocculent myosin was strained off, dissolved in a little water, and precipitated by pouring the solution into a large volume of water. It was

ANALYSIS OF MYOSIN B, FROM OX MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T. °C.	N found. Pressure mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ from the Ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of Ash. %
I	0·4306	0·2719	7·01	0·8237	52·16	----	----	----	----	----	----	----	----	----	----	----
II	0·3932	0·2500	7·06	0·7515	52·12	----	----	----	----	----	----	----	----	----	----	----
III	0.5061	----	----	----	----	67·8	9·8	764·6	16·34	----	----	----	----	----	----	----
IV	0·6005	----	----	----	----	81·3	9·7	762·6	16·48	----	----	----	----	----	----	----
V	1·0425	----	----	----	----	----	----	----	----	0 0072	0·69	----	----	----	----	----
VI	0·6690	----	----	----	----	----	----	----	----	0·0046	0·69	----	----	----	----	----
VII	1·7115	----	----	----	----	----	----	----	----	----	----	0·0046	0·05	----	----	----
VIII	0·6277	----	----	----	----	----	----	----	----	----	----	----	----	0·0597	1·31	1·26
IX	0·6358	----	----	----	----	----	----	----	----	----	----	----	----	0·0594	1·29	1·24

Percentage composition of the ash-free substance.

							Average.
C	52·53	52·48	----	----	----	----	*52·51*
H	7·06	7·11	----	----	----	----	*7·09*
N	----	----	16·46	16·59	----	----	*16·53*
S	----	----	----	----	1·26	1·24	*1·25*
O	----	----	----	----	----	----	*22·62*
							100·00

ANALYSIS OF MYOSIN C. FROM SHEEP'S MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram	C %	N found c. c.	N found T. °C.	N found Pressure mm	N %	Ash found gram	Ash %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of ash. %
I	0·4945	0·3150	7·08	0·9603	52·95	....	....	....	....	....	....	....	....	....	....	....
II	0·3539	0·2255	7·08	0·6863	52·88	....	....	....	....	....	....	....	....	....	....	....
III	0·4600	....	....	....	....	61·8	10·2	761·1	16·29	....	....	....	....	....	....	....
IV	0·7477	....	....	....	....	101·3	10·2	762·1	16·41	....	....	....	....	....	....	....
V	0·5170	....	....	....	....	....	....	....	....	0·0031	0·60	....	....	....	....	....
VI	0·8969	....	....	....	....	....	....	....	....	0·0051	0·57	....	....	....	....	....
VII	1·4139	....	....	....	....	....	....	....	....	....	....	0·0037	0·036		....	....
VIII	0·7761	....	....	....	....	....	....	....	....	....	....	....	....	0·0699	1·24	1·20
IX	0·7059	....	....	....	....	....	....	....	....	....	....	....	....	0·0667	1·29	1·25

Percentage composition of the ash-free substance.

							Average.
C	53·27	53·20	....	....	....	....	*53·24*
H	7·12	7·12	....	....	....	....	*7·12*
N	....	....	16·39	16·51	....	....	*16·45*
S	....	....	....	....	1·20	1·25	*1·23*
O	....	....	....	....	....	....	*21·96*
							100·00

then washed with water, alcohol, and ether, and dried at 110° C. (D^{II}).

The composition of both products is shown in the accompanying tables.

From the analytical data it is seen that the two preparations show close agreement, although there are minor differences; D^{II}, for example, containing a slightly higher percentage of carbon and a correspondingly lower percentage of nitrogen than D^{I}. Further, D^{II} contains less than half as much ash as the other preparation. Both show fairly close agreement with the myosins from ox muscle, with perhaps a slightly higher average percentage of nitrogen.

Myosin E, from fish.

So far as we are aware, little attention has been paid to the myosin from fish flesh. Myosin is assumed to be present and is supposed to be of the same general nature as the myosin from other forms of muscle tissue.

We first tried the separation of myosin from fresh cod (*Gadus callarias* or *G. morrhua*), using 2 kilos. of the fresh, léan tissue obtained in market. The final ammonium chloride extract (15 per cent.) failed to give anything more than an insignificant precipitate, either by dilution with water or by saturation of the fluid with sodium chloride.

A second preparation was attempted from the flesh of the halibut (*Hippoglossus vulgaris*); 2·5 kilos. of fresh tissue, free from fasciæ, fat and integument were thoroughly extracted with thymolized water for several days, the chopped tissue being well rubbed up with the water to insure complete removal of soluble albumins, etc. The thoroughly washed fibre was then triturated with a 15 per cent. ammonium chloride solution and allowed to stand in contact with it for 24 hours. The filtered fluid gave a decided precipitate on boiling, and also on addition of salt to saturation.

Myosin was separated from the ammonium chloride solution by dialysis as a more or less gelatinous precipitate, and was prepared for analysis by washing with thymolized water, and treatment with alcohol and ether.

Dried at 110° C. until of constant weight, it yielded the following results:

I. 0·3835 gram substance gave 0·2043 gram H_2O = 6·08 per cent. H and 0·6257 gram CO_2 = 51·16 per cent. C.

ANALYSIS OF MYOSIN D[1], FROM CALF'S MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T °C.	N found. Pressure mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of ash %
I	0·3541	0·2201	6·91	0·6646	51·18	---	---	----	---	----	---	----	---	----	- -	-----
II	0·3925	0·2439	6·93	0·7395	51·33	---	---	----	---	----	---	----	---	----	---	-----
III	0·6283	----	----	----	----	87·4	9·8	749·8	16·64	----	---	----	---	----	---	-----
IV	0·6065	----	----	----	---	82·6	10·7	768·1	16·64	----	---	----	---	----	---	-----
V	0·9831	----	-- -	-- -	----	---	---	----	---	0·0291	2·95	----	---	---	---	-----
VI	0·7361	----	----	----	----	---	---	----	---	0·0214	2·91	----	---	----	---	-----
VII	1·7182	----	----	----	----	---	---	----	---	--	---	0·0130	0·10	-	---	-----
VIII	0·6707	----	----	----	----	---	---	----	---	----	---	----	---	0·0679	1·39	1·29
IX	0·5690	----	----	----	----	- -	---	----	---	----	---	----	---	0·0575	1·39	1·29

Percentage composition of the ash-free substance.

							Average
C	52·79	52·88	----	-	----	----	*52·84*
H	7·11	7·11	----	----	- -	----	*7·11*
N	----	----	17·14	17·14	---	----	*17·14*
S	----	---	--	----	1·33	1·33	*1·33*
O	----	----	----	----	----	----	*21·58*
							100·00

ANALYSIS OF MYOSIN D^{II}, FROM CALF'S MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T. °C.	N found. Pressure. mm.	N %	Ash found. gram.	Ash. %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of ash. %
I	0·3284	0·2078	7·03	0·6803	52·34	...	...	...	...	...	...	...	...	...	...	...
II	0·2290	0·1457	7·07	0·4396	52·35	...	...	...	...	...	...	...	...	...	...	...
III	0·6012	...	...	...	...	82·8	11·0	768·1	16·81	...	...	...	...	...	...	...
IV	0·5682	...	...	...	...	78·5	11·4	762·5	16·71	...	...	...	...	...	...	...
V	0·5994	...	...	...	...	...	...	...	...	0·0070	1·17	...	...	...	...	...
VI	0·8061	...	...	...	...	...	...	...	...	0·0096	1·19	...	...	...	...	...
VII	1·4025	...	...	...	...	...	...	...	...	...	...	0·0037	0·036	...	...	...
VIII	0·5575	...	...	...	...	...	...	...	...	...	...	...	...	0·0521	1·28	1·24
IX	0·6235	...	...	...	...	...	...	...	...	...	...	...	...	0·0576	1·27	1·23

Percentage composition of the ash-free substance.

							Average
C	52·97	52·97	...	...	...	...	*52·97*
H	7·11	7·15	...	...	...	...	*7·13*
N	...	...	17·01	16·91	...	...	*16·96*
S	...	...	...	...	1·26	1·24	*1·25*
O	...	...	...	...	...	...	*21·69*
							100·00

ANALYSIS OF MYOSIN F[1], FROM OX MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T °C	N found. Pressure. mm	N %	Ash found gram	Ash %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of ash. %
I	0·4229	0·2661	6·99	0·8109	52·29	----	----	----	----	----	----	----	----	----	----	----
II	0·3655	0·2315	7·03	0·7019	52·36	----	----	----	----	----	----	----	----	----	----	----
III	0·6159	----	----	----	----	84·3	10·1	754·3	16·45	----	----	----	----	----	----	----
IV	0·6100	----	----	----	----	83·6	9·2	755·7	16 57	----	----	----	----	----	----	----
V	0 7144	----	----	----	----	----	----	----	----	0·0088	1·23	----	----	----	----	----
VI	0·7000	----	----	----	----	----	----	----	----	0·0090	1·29	----	----	----	----	----
VII	1·4144	----	----	----	----	----	----	----	----	----	----	0·0050	0·05	----	----	----
VIII	0·6112	----	----	----	----	----	----	----	----	----	----	----	----	0·0579	1·30	1·25
IX	0·5189	----	----	----	----	----	----	----	----	----	----	----	----	0·0529	1·40	1·35
X	0·5882	----	----	----	----	----	----	----	----	----	----	----	----	0·0545	1·27	1·22

Percentage composition of the ash-free substance.

								Average
C	52·95	53·04	----	----	----	----	----	*52·99*
H	7·08	7·13	----	----	----	----	----	*7·11*
N	----	----	16·67	16·78	----	----	----	*16·73*
S	----	----	----	----	1·27	1·37	1·24	*1·29*
O	----	----	----	----	----	----	----	*21·88*
								100·00

ANALYSIS OF MYOSIN F[II], FROM OX MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T. °C.	N found. Pressure. mm	N %	Ash found. gram.	Ash %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of ash. %
I	0·3369	0·2113	7·00	0·6381	51·63	...	...	......	...	....	...	....	...	....	...	.....
II	0·4515	0·2804	6·92	0·8582	51·83	...	...	......	...	....	...	...	...	....	...	.....
III	0·6228	......	...	......	...	84·4	10·8	758·0	16·33	....	..	....	...	....	...	.....
IV	0·4050	......	...	.....	...	55·5	10·1	754·2	16·48	....	...	....	...	....	...	.....
V	0.5905	......	...	......	...	...	...	......	...	0·0123	2·08	....	...	....	...	.....
VI	0·7229	......	...	......	...	...	...	......	...	0·0146	2·02	....	...	....	...	.....
VII	1·3184	......	...	......	...	...	...	......	...	....	...	0·0074	0·077	...	...	.....
VIII	0·5634	......	...	......	..	...	...	......	...	....	...	....	...	0·0565	1·38	1·30
IX	0·7243	......	...	......	...	...	...	......	...	....	...	....	...	0·0705	1·32	1·24

Precentage composition of the ash-free substance.

							Average.
C	52·73	52·92	....	....	....	...	*52·83*
H	7·14	7·05	....	....	....	.	*7·10*
N	....	....	16·67	16·81	....	...	*16·74*
S	..	..	....	....	1·38	1·28	*1·31*
O	....	....	....	....	....	....	*22·02*
							100·00

II. 0·4895 gram substance gave 67·8^{cc} N at 15·4° C. and 761·6^{mm} pressure = 16·50 per cent. N.

III. 0·4939 gram substance gave 0·0116 gram ash = 2·35 per cent.

Percentage composition of ash-free substance,

C 52·39, H 6·97, N 16·74.

The amount of myosin obtained from the fish muscle was not at all commensurate with the amount of flesh experimented with. Danilewsky,* however, found in the muscle tissue of the perch 8·56 per cent. of myosin as contrasted with 7·5 per cent. in ox muscle. Whether our inability to separate a corresponding amount from the tissue of the cod and halibut was due to the character of the tissue, to its possible staleness, or to inferior methods of separation we cannot say. Certainly, the yield of myosin in our case was not as great as from the muscle tissue of the ox, calf, lamb or sheep.

In composition, and in such reactions as we were able to try, the fish myosin was not unlike the myosin from other preparations.

Myosin F, from ox muscle.

A solution in 15 per cent. ammonium chloride was prepared as in preceding cases and the myosin precipitated by addition of a large amount of water.

One half of the precipitated myosin was washed with water until all ammonium chloride was removed, then with alcohol and ether, and dried for analysis (F^{I}).

The other half of the myosin was washed somewhat with water, not enough to render it insoluble, then dissolved in 10 per cent. sodium chloride solution, reprecipitated by dilution with water, thoroughly washed and dried (F^{II}).

The composition of the two products is shown in the accompanying tables. The results show close agreement with each other, and with the preceding preparations.

Myosin G, from ox muscle.

According to Danilewsky, a 15 per cent. solution of ammonium chloride is stronger than necessary for the extraction of myosin from

* Ueber die Abhänghigkeit der contractionsart der muskeln von der mengen verhältnissen einiger ihrer Bestandtheile. Zeitschrift für physiologische Chemie. Band vii, p. 124.

muscle tissue. In fact, microscopic examination showed that 15 per cent. solutions of this salt generally cause destruction of the muscle fibres, while weaker solutions of the ammonium salt, as 5 per cent., extract the myosin equally well, without injuring the structural elements in the least.

Thinking that possibly a purer myosin might be obtained by the use of a weaker salt solution, several kilos. of thoroughly washed muscle tissue were rubbed up with an excess of 5 per cent. ammonium chloride and kept in contact with it for 48 hours. From the filtered solution, myosin was separated by addition of a large volume of water and the product washed and dried for analysis (G^{I}).

The tissue remaining after extraction as described, was treated with a fresh 5 per cent. solution of ammonium chloride, and from this fluid a second precipitate of myosin was obtained by addition of water. This also was washed and dried for analysis (G^{II}).

The residue of tissue still remaining was then extracted with a 15 per cent. solution of ammonium chloride. The extract so obtained gave a flocculent precipitate on saturation with sodium chloride, and a coagulum appeared on boiling the solution, but no precipitate could be obtained on addition of a large volume of water. It is thus evident that there was an almost complete extraction of myosin by the 5 per cent. solution of the ammonium salt.

On precipitating the small amount of myosin present in the 15 per cent. ammonium chloride solution by saturation of the fluid with salt, a clear filtrate was obtained which gave a turbidity on boiling and also on addition of acetic acid and potassium ferrocyanide, thus showing the presence of a small amount of soluble albumin.

The composition of the two myosins, as seen from the accompanying tables, does not differ at all from that of other preparations.

Myosin H, from muscle of sheep.

In this preparation, the thoroughly washed and chopped muscle was partially extracted with a 5 per cent. ammonium chloride solution, and the myosin separated by addition of water. It was then washed and dried for analysis (H^{I}).

The residue of tissue was extracted with a 15 per cent. solution of ammonium chloride and the myosin separated from this solution, likewise, by addition of water (H^{II}).

ANALYSIS OF MYOSIN G[I], FROM OX MUSCLE.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found gram.	C %	N found c. c.	N found T. °C.	N found Pressure mm.	N %	Ash found. gram	Ash %	$BaSO_4$ from the ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH+KNO_3$ gram.	S %	S after deducting S of ash. %
I	0·3877	0·2482	7·11	0 7487	52·31	...	...	...	...	...	...	...	...	...	...	...
II	0·4690	0·2974	7·05	0·8979	52·21	...	...	...	...	...	...	...	...	...	...	...
III	0·6343	...	...	...	...	85·5	12·0	761·8	16·24	...	...	...	...	...	...	...
IV	0.5718	...	...	...	...	77·6	13·6	765·6	16·32	...	...	...	...	...	...	...
V	0·4814	...	...	...	...	...	...	...	...	0·0071	1·47	...	...	...	...	...
VI	0·7234	...	...	...	...	...	...	...	...	0·0109	1·51	...	...	...	...	...
VII	1·2048	...	...	...	...	...	...	...	...	...		0·0071	0·08	...	...	...
VIII	0·5281	...	...	...	...		...	...	...	...	...	...	...	0·0484	1·26	1·18
IX	0·5719	...	...	...	...	...	...	...	...	...	...	...	...	0·0506	1·22	1·14

Percentage composition of the ash-free substance.

							Average.
C	53·09	53·00	...	...	...	...	*53·05*
H	7·22	7·16	...	...	...	...	*7·19*
N	...	...	16·47	16·57	...	...	*16·52*
S	...	...	...	...	1·20	1·16	*1·18*
O	...	...	...	...	...	...	*22·06*
							100·00

ANALYSIS OF MYOSIN G^{II}, FROM OX MUSCLE.

No.	Substance used. gram	H_2O found. gram.	H %	CO_2 found. gram	C %	N found. c. c.	T. °C.	Pressure. mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ from the Ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with KOH + KNO_3 gram.	S %	S after deducting S of Ash %
I	0·4788	0·3021	7·01	0·9077	51·68	....	....	....	....	....	....	....	....	....	....	....
II	0·3802	0·2361	6·90	0·7221	51·78	....	....	....	....	....	....	....	....	....	....	....
III	0·8286	....	....	....	....	113·3	13·6	765·8	16·43	....	....	....	....	....	....	....
IV	0·4869	....	....	....	....	66·5	14·1	768·4	16·49	....	....	....	....	....	....	....
V	0·5740	....	....	....	....	....	....	....	....	0·0121	2·11	....	....	....	....	....
VI	0·5348	....	....	....	....	....	....	....	....	0·0105	1·96	....	....	....	....	....
VII	1·0088	....	....	....	....	....	....	....	....	....	....	0·0055	0·075	....	....	....
VIII	0·5490	....	....	....	....	....	....	....	....	....	....	....	....	0·0488	1·22	1·14
IX	0·5918	....	....	....	....	....	....	....	....	....	....	....	....	0·0517	1·20	1·12

Percentage composition of the ash-free substance.

							Average.
C	52·77	52·86	....	....	....	....	*52·82*
H	7·16	7·05	....	....	....	....	*7·11*
N	....	....	16·78	16·83	....	....	*16·80*
S	....	....	....	....	1·17	1·15	*1·16*
O	....	....	....	....	....	....	*22·11*
							100·00

ANALYSIS OF MYOSIN H[1], FROM MUSCLE OF SHEEP.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c c	N found. T °C	N found. Pressure mm.	N %	Ash found. gram.	Ash. %	$BaSO_4$ from the Ash. gram.	S of Ash. % of sub	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of Ash. %
I	0·3904	0·2441	6·95	0·7440	51·96	...	...	....	...	...	..	......	...	.	...	....
II	0·4537	0·2854	7·01	0·8637	51·94	...	...	......	...	....	...	......	...	....	...	....
III	0·2960	......	...	......	...	40·9	14·3	766·4	16·63	....	...	......	...	....	...	....
IV	0·5605	......	...	......	...	...	...	.. ...	...	0·0096	1·71	.. ..	...	.. .	...	....
V	0·6490	......	...	....	...	...	..	......	...	0·0108	1·67	......	..	....	...	....
VI	1·2095	......	..	......	...	...	...	.. ..	..	...	...	0·0084	0·04	..	...	....
VII	0·5423	......	...	......	...	...	...	......	...	..	...	.... .	..	0·0464	1·18	1·14
VIII	0·5589	......	...	......	...	...	...	......	...	....	...	......	...	0·0553	1·35	1·31
IX	0·5238	. ....	...	.. ...	...	...	...	.... .	...	....	...	......	...	0·0526	1·38	1·34

Percentage composition of the ash-free substance.

							Average
C	52·86	52·82	....	...	.. .	....	*52·84*
H	7·07	7·13	....	....	....	....	*7·10*
N	....	....	16·91	...	....	....	*16·91*
S	...	....	....	1·15	1·32	1·36	*1·28*
O	...	....	....	....	....	....	*21·87*
							100·00

ANALYSIS OF MYOSIN H^{II}, FROM MUSCLE OF SHEEP.

No.	Substance used. gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c. c.	N found. T. °C.	N found. Pressure mm.	N %	Ash. found. gram.	Ash. %	$BaSO_4$ from the Ash. gram.	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of Ash. %
I	0·4075	0·2559	6·97	0·7716	51·63	...	...	......	...	....	...	....	.	....	...	....
II	0·2374	0·1497	7·01	0·4526	51·99	...	...	......	...	....	...	...	...	....	...	....
III	0·5898	......	...	......	...	81·3	14·4	767·4	16·61	...	...	....	...	....	...	....
IV	0·2675	......	...	......	...	36·0	14·9	765·5	16·56	....	...	....	...	....	...	....
V	0·6164	......	...	......	...	...	...	......	...	0·0090	1·46	...	...	....	...	...
VI	0·5958	......	...	......	...	...	...	....	...	0·0085	1.43	....	...	....	...	....
VII	1·2122	......	...	......	..	...	...	......	...	....	...	0·0048	0·05	....	...	....
VIII	0·5413	......	...	......	...	...	...	......	...	...	...	....	...	0·0483	1·22	1·17
IX	0·4759	......	...	......	...	...	...	......	...	....	...	....	...	0·0403	1·16	1·11

Percentage composition of the ash-free substance. Average.

							Average
C	52·39	52·74	...	....	....	....	*52·57*
H	7·08	7·11	....	....	...	....	*7·10*
N	....	....	16·85	16·84	....	....	*16·84*
S	....	....	....	....	1·19	1·13	*1·16*
O	....	..	....	....	....	....	*22·33*
							100·00

ANALYSIS OF MYOSIN I, FROM MUSCLE OF OX.

No.	Substance used gram.	H_2O found. gram.	H %	CO_2 found. gram.	C %	N found. c.c.	T. °C.	Pressure. mm.	N %	Ash found. gram.	Ash %	$BaSO_4$ from the Ash. gram	S of Ash. % of sub.	$BaSO_4$ after fusion with $KOH + KNO_3$ gram.	S %	S after deducting S of Ash. %
I	0·3665	0·2313	7·01	0·7053	52·48	...	...	...	...	...	...	...	...	...	...	...
II	0·4900	...	...	0·9404	52·48	...	...	...	...	...	...	...	...	...	...	...
III	0·2913	0·1868	7·13	0·5596	52·38	...	...	...	...	...	...	...	...	...	...	...
IV	0·7746	...	...	...	...	109·1	15·4	759·8	16·73	...	...	...	...	...	...	...
V	0·5013	...	...	...	...	70·6	14·7	757·8	16·72	...	...	...	...	...	...	...
VI	0·7524	...	...	...	...	105·9	15·0	760·7	16·77	...	...	...	...	...	...	...
VII	0·6629	...	...	...	...	...	...	...	...	0·0043	0·65	...	...	...	...	...
VIII	0·6741	...	...	...	...	...	...	...	...	0·0046	0·68	...	...	...	...	...
IX	1·0959	...	...	...	...	...	...	...	...	...	...	0·0020	0·025	...	...	...
X	0·4967	...	...	...	...	...	...	...	...	...	...	...	...	0·0458	1·26	1·23
XI	0·5992	...	...	...	...	...	...	...	...	...	...	...	...	0·0552	1·28	1·25

Percentage composition of the ash-free substance.

									Average
C	52·82	52·83	52·73	...	...	...	...	...	*52·79*
H	7·06	...	7·17	...	...	...	...	...	*7·12*
N	...	...	...	16·86	16·83	16·88	...	...	*16·86*
S	...	...	...	...	...	...	1·25	1·27	*1·26*
O	...	...	...	...	...	...	...	...	*21·97*
									100·00

RÉSUMÉ OF THE ANALYTICAL RESULTS.

	C	H	N	S	O
Myosin A, from ox	52·84	7·12	16·89	1·49	21·66
" B, " "	52·51	7·09	16·53	1·25	22·62
" C, " sheep	53·24	7·12	16·45	1·23	21·96
" D', " calf	52·84	7·11	17·14	1·33	21·58
" D", " "	52·97	7·13	16·96	1·25	21·69
" E, " halibut	52·39	6·97	16·74	...	
" F', " ox	52·99	7·11	16·73	1·29	21·88
" F", " "	52·83	7·10	16·74	1·31	22·02
" G', " "	53·05	7·19	16·52	1·18	22·06
" G", " "	52·82	7·11	16·80	1·16	22·11
" H', " sheep	52·84	7·10	16·91	1·28	21·87
" H", " "	52·57	7·10	16·84	1·16	22·33
" I, " ox	52·79	7·12	16·86	1·26	21·97
Average	52·82	7·11	16·77	1·27	21·90
Fibrinogen*	52·93	6·90	16·66	1·25	22·26
Fibrin*	52·68	6·83	16·91	1·10	22·48
Paraglobulin*	52·71	7·01	15·85	1·11	23·32
Egg albumin†	52·18	6·98	15·81	1·87	23·21

* Hammarsten, Jahresbericht der Thierchemie, vol. x, p. 11.

† Chittenden and Bolton Studies from Laboratory of Physiological Chemistry, Yale University, vol ii, p. 134.

The two products are seen to be practically identical in composition, and show close agreement with the other preparations of myosin.

Myosin I, from muscle of ox.

This, the last product analyzed, was obtained from an ammonium chloride extract of the washed muscle tissue from a freshly killed ox, by dialysis. After being washed and dried at 110° C. it was analyzed with the results shown in the accompanying table.

On comparing now the composition of the thirteen preparations of myosin analyzed, there is seen to be a very close agreement throughout. Further, on comparing the average of the analytical results with Hammarsten's figures for fibrinogen, the composition of the two bodies is seen to be almost identical. Compared with egg albumin, the most striking difference in composition is the low content of sulphur, and even if we assume with Danilewsky* that the sulphur of the ash comes from the sulphur of the myosin the correction therefor would not materially lessen the difference. Myosin also contains nearly one per cent. more nitrogen than egg albumin.

Coagulation of myosin solutions

According to Kühne,† the coagulation of myosin in a 10 per cent. sodium chloride solution occurs at 55–60° C. Weyl‡ obtained similar results. Danilewsky§ states that a 12–15 per cent. ammonium chloride solution of myosin becomes somewhat turbid at 42–43° C., decidedly turbid at 45–50° C., while at 55° C. a flocculent precipitate separates. The same investigator also found that the more concentrated the ammonium chloride solution was, the lower the temperature at which the turbidity and separation of a precipitate occurred, although never below 40° C. In common with other proteid bodies a slight degree of acidity lowers the temperature of coagulation, while a corresponding degree of alkalinity raises it. According to the recent

* Zeitschrift für Physiologische Chemie, Band v, p 161.

† Lehrbuch der Physiologischen Chemie, p 275.

‡ Zeitschrift für Physiologische Chemie, Band I, p. 77

§ Zeitschrift für Physiologische Chemie, Band v, p. 160.

work of Halliburton,* muscle-clot or myosin is formed from a substance (myosinogen) in the muscle-plasma which coagulates by heat at 47° C. and 56° C., thus indicating that it probably consists of two distinct proteids which coagulate at these temperatures respectively. Further, Halliburton considers that whenever myosin is dissolved in a suitable saline solution, it is at once re-converted into myosinogen, or rather into two proteids which resemble myosinogen in that they have the same heat coagulation temperatures and that they are convertible into myosin by dilution of their saline solutions. In salted muscle-plasma, Halliburton recognizes five distinct proteid bodies, distinguishable by fractional heat coagulation, viz :

47° C., a flocculent, somewhat sticky precipitate.
56° C., a more abundant and very sticky precipitate.
63° C., a finely flocculent precipitate, not sticky.
73° C., a finely flocculent precipitate, not sticky.
A non-coagulable albumose.

Of these, the two proteids coagulating at 47° C. and 56° C., make up the muscle-clot or myosin.

With these preliminary statements, we proceed to the results obtained in our study of the coagulation points of the different myosins, simply prefacing it with the explanation that our experiments were performed previous to reading Halliburton's paper. Naturally, the temperature of coagulation offers the simplest and surest means, in conjunction with the determination of composition, of detecting any difference in the character of the myosins from different sources. And with this as the main object the following experiments were tried. In every experiment, the muscle tissue was chopped quite fine and very thoroughly extracted with water, well thymolized, prior to solution of the myosin with the saline fluid.

We first demonstrated to our satisfaction that a 5 per cent. ammonium chloride solution of myosin invariably coagulates at a lower temperature than a 5 per cent. sodium chloride solution, and further, that the original saline extract of washed muscle shows approximately the same temperature of coagulation as the salt solution of precipitated myosin.

* Journal of Physiology, vol. viii, p. 148.

		Turbidity.	Flocculent precipitate.
A.	5 per cent. NH_4Cl extract of sheep's muscle.	43° C.	47° C.
B.	5 per cent. NH_4Cl solution of H_2O precipitate of myosin, from A.	44°	48°
C.	5 per cent. NaCl solution of H_2O precipitate of myosin, from A.	57°	62°
D.	5 per cent. NH_4Cl extract of ox muscle.	40°	44°
E.	5 per cent. NaCl solution of H_2O precipitate of myosin, from D.	57°	62°
F.	5 per cent. NH_4Cl extract of lamb's muscle.	44°	47°
G.	5 per cent. NaCl solution of H_2O precipitate of myosin, from F.	51°	57°
H.	5 per cent. NH_4Cl extract of calf's muscle.	41°	44°
I.	5 per cent. NaCl extract of same.	53°	56°
J.	5 per cent. NH_4Cl extract of breast muscle from chicken.	43°	46°
K.	5 per cent. NaCl extract of same.	53°	57°
L.	5 per cent. NH_4Cl extract of leg muscle from chicken.	45°	48°
M.	5 per cent. NaCl extract of same.	56°	61°

In all of these trials, the filtrate from the flocculent precipitate failed to show any further coagulation, although the temperature was raised to above 75° C.

The results show a varying difference in the coagulation points of the ammonium and sodium chloride solutions, but on an average the difference amounts to eleven degrees. It further appears that the myosin solutions (in NaCl) from lamb, calf, and chicken muscle have a somewhat lower coagulating point than the corresponding extracts from ox and sheep muscle.

In another series of results, shown in the accompanying table, the same difference in coagulation point shows itself, and it is further seen that the extracts from rabbit's and halibut's muscle have a still lower coagulating point. Further, in this series of experiments, the filtrate from the first coagulum gave a second precipitate on raising the temperature, and in the case of the muscle from ox and lamb, a third coagulum was obtained at 74° C.

COAGULATION OF MYOSIN SOLUTIONS.

Nature of the Solution	Coagulation of the Solution.		Coagulation of the filtrate.	
5 per cent. NaCl.	Turbidity	Flocculent precipitate	Turbidity.	Flocculent precipitate
Sheep's muscle.	57 C.	63° C.	68° C.	73° C.
Ox "	58	63°	66°	72°
Rabbit's "	52°	57°	62°	66°
Pig's "	56°	60°	65°	70°
Lamb's "	53	60°		
Calf's "	53°	57°	66°	70°
Halibut's "	47	58°	55°	60°
Ox "	57°	62°	64°	66°
Lamb's "	55	62°	63°	68°
Calf's "	53°	59	63°	66°
Chicken " (breast)	53°	57	61°	67°
" " (leg)	56°	61°		
Lobster* "	65			

The results collectively fail to show the presence of a proteid coagulating at 47° C., given by Halliburton as characteristic of myosin, but they do show a coagulum at 56° C. or thereabouts, corresponding to Halliburton's second proteid. This difference is possibly due to the character of the saline solution, Halliburton having used a magnesium or ammonium sulphate solution. The coagulums obtained at higher temperatures show an approach, at least, to the figures found by Halliburton in his fractional coagulation of salted muscle-plasma.

* Lobster did not yield enough myosin to permit of an exact determination, still a decided turbidity was present at 65° C. The addition of water to the 5 per cent. NaCl solution, gave a flocculent precipitate which changed to a glairy mass resembling much the white of an egg. On washing with water it became insoluble, but differed in general appearance from similar precipitates from other sources.

A careful study of the preceding results, combined with what has been known concerning the chemical properties of myosin, seems to justify the assumption that myosin, as it occurs throughout the animal kingdom, is a single chemical compound, doubtless formed, as suggested by Halliburton, by the interaction of one or more myosinogens and a ferment body. That myosin is a single body, is supported by the observed agreement in chemical composition and the general uniformity in the temperature of coagulation of myosin from various animal sources, and is furthermore to be inferred from the similarity in function of the tissue in which it occurs most abundantly.

VIII.—Myosinoses. By W. Kühne and R. H. Chittenden.

Of the primary digestion products of the various proteids, the albumoses from fibrin * and egg albumin † have been more or less carefully examined and analyzed, as also the globuloses,‡ the caseoses,§ and elastinoses. ‖ Further, the vitelloses ¶ have likewise been prepared from crystalline phyto-vitellin and their properties ascertained. With the hope of gradually completing the list we have undertaken a study of the primary digestion products of myosin, the results of which we now present.

For the preparation of myosin, large quantities of finely divided ox muscle were extracted with cold water until the fluid no longer gave reaction for albumin, after which the tissue was placed in an excess of a 15 per cent. ammonium chloride solution, and the myosin ultimately precipitated from the filtered fluid by dialysis.** The extraction of myosin with ammonium chloride, after the method of Danilewsky,†† is far better in every way than the older method of extraction with 10 per cent. sodium chloride, since myosin is dissolved more rapidly and completely by the ammonium salt, even from coarsely divided muscle, and at the same time forms a more easily filterable fluid. Further, the advantage of precipitating the myosin by dialysis in running water, instead of pouring the ammonium chloride solution into a large excess of water, consists in the avoidance of the large volumes of fluid necessary in the preparation of such a large quantity of myosin, while at the same time the myosin is obtained equally free from soluble salts. At the best, however, the preparation of such a quantity of myosin as was needed in the present investigation involved a large amount of labor and a comparatively low temperature, hence compelling us to take the winter season for the work. The united products obtained in this manner were treated ultimately with dilute alcohol, whereby the semi-gelatinous mass was naturally more or less shrunken, and finally with ether.

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* Zeitschrift für Biologie, Band xix, p. 159 and Band xx, p. 11.

† Studies from Laboratory of Physiological Chemistry, Yale University, vol. ii, p. 126.

‡ Zeitschrift für Biologie, Band xxii, p. 409.

§ This volume, p. 66. ‖ This volume, p. 19.

¶ Ueber vitellosen, by Dr. R. Neumeister. Zeitschrift für Biologie. Band xxiii, p. 2.

** See the preceding article.

†† Zeitschrift für Physiologische Chemie, Band v, p. 158

A sample of the product, carefully dried at 110° C. until of constant weight, yielded the following results on analysis.

Myosin.

I. 0·3665 gram substance gave 0·2313 gram H_2O = 7·01 per cent. H and 0·7053 gram CO_2 = 52·48 per cent. C.

II. 0·4900 gram substance gave 0·9404 gram CO_2 = 52·48 per cent. C.

III. 0·2913 gram substance gave 0·1868 gram H_2O = 7·13 per cent. H and 0·5596 gram CO_2 = 52·38 per cent. C.

IV. 0·7746 gram substance gave 109·1 c.c. N at 15·4° C. and 759·8 mm pressure = 16·73 per cent. N.

V. 0·5013 gram substance gave 70·6 c.c. N at 14·7° C. and 757·8 mm pressure = 16·72 per cent. N.

VI. 0·7524 gram substance gave 105·9 c.c. N. at 15·0° C. and 760·7 mm pressure = 16·77 per cent. N.

VII. 0·6629 gram substance gave 0·0043 gram ash = 0·65 per cent.

VIII. 0·6741 gram substance gave 0·0046 gram ash = 0·68 per cent.

IX. The ash from 1·3370 grams substance gave 0·002 gram $BaSO_4$ = 0·02 per cent. S.

X. 0·4967 gram substance gave by fusion with KOH + KNO_3, after Hammarsten's method, 0·0458 gram $BaSO_4$ = 1·26 per cent. S; deducting 0·02 per cent. S of ash = 1·24 per cent.

XI. 0·5992 gram substance gave after fusion with KOH + KNO_3 0·0552 gram $BaSO_4$ = 1·28 per cent. S; deducting 0·02 per cent. = 1·26 per cent.

Percentage composition of ash-free myosin.

									Average
C	52·82	52·83	52·73	....	....	....	....	....	52·79
H	7·06	....	7·17	....	....	....	....	....	7·12
N	....	....	....	16·86	16·83	16·88	....	....	16·86
S	....	....	....	....	....	....	1·25	1·27	1·26
O	....	....	....	....	....	....	....	....	21·97
									100·00

The ash consisted almost entirely of calcium phosphate.

Digestion of Myosin.

The myosin purified as described with alcohol and ether, proved so resistant to the action of pepsin-hydrochloric acid, that its diges-

tion could be accomplished only by repeated treatment with the ferment. The gastric juice at first emyloyed was prepared by warming 120 grams of mucous membrane from a pig's stomach with 1200 c. c. 0·4 per cent. hydrochloric acid for 24 hours at 41° C., filtration through paper, dilution of the acid fluid with an equal volume of water and further exposure to a temperature of 40° C. for four days, in order to convert any dissolved albumoses into peptone.

The digestive fluid so obtained contained 0·2 per cent. HCl and 0·5 per cent. solid matter.

200 grams of finely powdered myosin were placed in 2 litres of this gastric juice, 2 litres of 0·2 per cent. hydrochloric acid added and the whole warmed at 40° C. for two days. As only a little of the myosin appeared to be dissolved, the acidity was increased to 0·4 per cent. and the mixture continued at 40° C. for 24 hours longer. Although a large residue still remained undissolved, the entire mixture was made neutral with sodium hydroxide and strained through a cloth filter. The undigested residue, together with the abundant neutralization precipitate, was again warmed for several days at 40° C. with 2 litres of 0·4 per cent. hydrochloric acid containing 7·5 grams of scrapings from a stomach mucous membrane. After stopping the action of the pepsin by neutralization, this second digestive fluid was added to the first In spite of the energetic action of the pepsin (tested by allowing a little of the solution to act on boiled fibrin), there still remained considerable undissolved substance together with considerable neutralization precipitate, the whole apparently very resistant to the action of the ferment. In the united solutions there was present less than 100 grams of organic matter, of which it is fair to presume about 10·5 grams consisted of impurity in the form of substances from the stomach membrane. When it is remembered, however, that well prepared gastric juice contains only a very small amount of substances precipitable by the salts used in separation of the proteoses, it is fair to assume that this impurity in the digestive fluid is unimportant in the study of the myosinoses. In all, nearly 60 grams of myosinoses were obtained.

For separation of the myosinoses, the united neutral filtrates were concentrated to about one-sixth of their volume and saturated with crystals of rock salt, by which the fluid was converted into a gelatinous mass. On adding saturated salt solution to a portion of the filtered fluid it was rendered decidedly turbid; consequently, three volumes of a saturated sodium chloride solution were added to the mixture, after which it was found that neither salt in substance or in solution

would give any further turbidity. From this it is evident that the neutral digestive fluid is not completely precipitated by simple saturation with sodium chloride, but that complete precipitation is reached only when the absolute quantity of salt stands in a certain proportion to the proteoses present.

After this separation of the first portion of the myosinoses, which would naturally consist of proto, hetero, and dysmyosinose, the remainder were precipitated first with salt-saturated 30 per cent. acetic acid and then, after removal of the sodium chloride by dialysis, with neutral ammonium sulphate. In the solution remaining from this last precipitation, peptone was detected by the biuret reaction.

Protomyosinose.

The sodium chloride precipitate, after thorough washing with saturated salt solution, dissolved almost entirely on being rubbed up with water.

What did remain undissolved, showed the reactions of dysalbumose. It was insoluble in water and in salt solutions of all strengths, but easily soluble in 0·1 per cent. hydrochloric acid, much more difficultly soluble in 0·5 per cent. sodium carbonate, by neutralization only partially precipitated and gave the biuret reaction. From the filtrate of the neutralized hydrochloric acid solution, some heteromyosinose in the form of a flocculent precipitate was obtained by dialysis. This hetero body was soluble in dilute sodium chloride solutions, insoluble in water, precipitable by salt in substance, and after the manner of the albumoses gave a precipitate with nitric acid in the cold, which disappeared as the mixture was warmed, reappearing as the solution cooled. This heteromyosinose, formed from dysmyosinose by a process of retrogression, amounted to considerable; about 1·5 grams.

Reactions of Protomyosinose.

In order to purify protomyosinose the aqueous solution of the substance was freed from sodium chloride by dialysis, by which only traces of heteromyosinose separated, and the solution evaporated to a thin syrup. The fluid was filtered from a slight flocculent albumin-like precipitate insoluble in hot water, somewhat further concentrated and the pure myosinose separated by alcohol. After washing with alcohol and ether it appeared as a light, white powder. The yield amounted to about ten grams.

The reactions of protomyosinose agree in general with those of protoalbumose, but with one important difference, viz: that an aqueous solution of the former, free from salt, of whatever concentration, is not rendered turbid by nitric acid. Addition of even a little sodium chloride to the acid fluid, however, is sufficient to cause a heavy precipitate, soluble as the mixture is warmed but reappearing as the solution cools. The precipitate is also soluble in an excess of the acid in the cold.

Protomyosinose is readily soluble in distilled water, the solution showing a weak, but unquestionably alkaline reaction. In this solution, as well as in a solution rendered acid by acetic acid, cupric sulphate produces a heavy turbidity, which on boiling almost entirely disappears. Acetic acid and potassium ferrocyanide produce a heavy precipitate, insoluble in glacial acetic acid. Neutral lead acetate gives no precipitate. Basic lead acetate and mercuric chloride both produce a heavy turbidity. An aqueous solution of the myosinose boiled with sodium hydroxide and lead acetate is colored deep brown or black; with sodium hydroxide and cupric sulphate a beautiful red. Concentrated sodium hydroxide, as in protoelastose, produces a heavy flocculent, gelatinous precipitate. By saturation of an aqueous solution of protomyosinose with sodium chloride, only a portion of the substance is precipitated; the portion remaining dissolved is precipitable by acid.

The composition of the substance, dried at 110° C. until of constant weight, is shown by the following analysis.

Protomyosinose.

I. 0·3722 gram substance gave 0·2387 gram H_2O = 7·12 per cent. H and 0·7090 gram CO_2= 51·95 per cent. C.

II. 0·4239 gram substance gave 0·2688 gram H_2O = 7·05 per cent H and 0·8048 gram CO_2= 51·77 per cent. C.

III. 0·3319 gram substance gave 0·2138 gram H_2O = 7·15 per cent. H and 0·6308 gram CO_2= 51·83 per cent. C.

IV. 0·4798 gram substance gave 67·5 c. c. N at 14·8° C. and 762·1 mm pressure = 16·79 per cent. N.

V. 0·5663 gram substance gave 78·3 c. c. N at 15·1° C. and 768·2 mm pressure = 16·64 per cent. N.

VI. 0·4429 gram substance gave 62·7 c. c. N at 15·8° C. and 758·2 mm pressure = 16·77 per cent. N.

VII. 0·5494 gram substance gave 0·0062 gram ash = 1·13 per cent.

VIII. 0·7080 gram substance gave 0·0081 gram ash=1·14 per cent.

IX. The ash from 1·2574 grams substance gave 0·0132 gram $BaSO_4$ = 0·14 per cent. S.

X. 0·4183 gram substance gave after fusion with KOH + KNO_3 0·0450 gram $BaSO_4$=1·47 per cent. S; after deducting 0·14 per cent. S of the ash = 1·33 per cent.

XI. 0·3963 gram substance gave after fusion with KOH + KNO_3 0·0411 gram $BaSO_4$= 1·42 per cent. S; deducting 0·14 per cent.= 1·28 per cent.

Percentage composition of ash-free protomyosinose.

									Average
C	52·58	52·35	52·41	...		....	.	.	52·48
H	7·19	7·12	7·22		.		. ..	.	7·17
N	....	..	.	16·98	16·88	16·96	..	....	16·92
S	.	...	....	....	....	....	1·35	1·30	1·32
O	....	....	....	....	....	.	....	.	22·16
									100·00

The ash contained only calcium phosphate and sulphate, with a little ferric oxide.

Deuteromyosinose.

This myosinose, as we have before mentioned, was obtained mainly by saturation with ammonium sulphate. After removal of the greater portion of protomyosinose by saturation with salt as described, deuteromyosinose was in part precipitated by salt-saturated acetic acid, but this precipitate could not be used on account of the large amount of proto body precipitated with it, as shown by the cupric sulphate reaction. This method of treatment, however, although necessitating the loss of considerable deuteromyosinose, enabled us to remove the proto body completely and thus ensure a pure specimen of deuteromyosinose on treatment of the filtrate with ammonium sulphate. Naturally, before saturating the fluid with the ammonium salt, the sodium chloride was removed by dialysis. The myosinose thus precipitated by saturation with ammonium sulphate was dissolved in water and dialyzed until the sulphate was entirely removed, or to such an extent that the fluid gave only the slightest turbidity with barium chloride even on long standing. We hastened the removal of the sulphate by repeated evaporation and renewed dialysis of the concentrated fluid. The substance was finally precipitated from the suitably concentrated fluid, as a white powder, by alcohol and washed with alcohol and ether. It weighed forty-five grams.

Reactions of deuteromyosinose.

Like the preceding myosinose, this body also reacts alkaline in an aqueous solution and this property exercises more or less of an influence on certain of its reactions. In order to convince ourselves of the absence of traces of either proto or heteromyosinose, we paid particular attention to the behavior of the deutero body towards the cupric sulphate reaction, which according to Neumeister's observations is a decisive test on this point. A fairly concentrated solution of our preparation was not rendered turbid by cupric sulphate in the cold, but after boiling and then cooling the mixture, a slight turbidity appeared. Solutions of the substance so concentrated as to be almost syrupy, gave a slight turbidity at once, the turbidity disappearing when the solution was heated and reappearing as the fluid cooled. By partial neutralization of the alkalinity of the myosinose solution, leaving the fluid, however, still alkaline to delicate test papers, precipitation by cupric sulphate was entirely prevented. As protomyosinose is precipitated by the copper salt equally well in an acid fluid, we are led to consider our deuteromyosinose entirely free from this impurity.

In general, deuteromyosinose shows much the same reactions as deuteroalbumose, but is somewhat different from the latter in that it is more difficultly precipitable. Acetic acid and nitric acid produce a precipitate only after addition of sodium chloride to saturation. Acetic acid and potassium ferrocyanide give a decided turbidity, not soluble in glacial acetic acid. Basic lead acetate and mercuric chloride both produce a precipitate, insoluble in excess of the reagent. Cold nitric acid quickly produces an intense yellow color. The biuret reaction comes out distinctly, but on boiling the myosinose with sodium hydroxide and lead acetate only a faint browning of the fluid is obtained.

The composition of the substance, dried at 110° C., is shown by the following analysis:

Deuteromyosinose.

I. 0·2121 gram substance gave 0·1394 gram H_2O = 7·30 per cent. H ar 0·3896 gram CO_2 = 50·09 per cent. C.

II. 0·2115 gram substance gave 0·1390 gram H_2O = 7·30 per cent. H and 0·3891 gram CO_2 = 50·12 per cent. C

III. 0·3880 gram substance gave 53·6 c. c. N at 15·0° C. and 762·5 mm pressure = 16·71 per cent. N.

IV. 0·2940 gram substance gave 41·4 c. c. N at 15·7° C. and 759·7 mm pressure = 16·72 per cent. N.

V. 0·4572 gram substance gave 0·0080 gram ash = 1·77 per cent.

VI. 0·5462 gram substance gave 0·0094 gram ash = 1·72 per cent.

VII. The ash from 1·0034 grams substance gave 0·0116 gram $BaSO_4$ = 0·15 per cent. S.

VIII. 0·3343 gram substance gave after fusion with KOH + KNO_3 0·0315 gram $BaSO_4$ = 1·29 per cent. S; after deducting 0·15 per cent. S of the ash = 1·14 per cent

IX. 0·4050 gram substance gave after fusion with KOH + KNO_3 0·0420 gram $BaSO_4$ = 1·42 per cent. S; deducting 0·15 per cent. = 1·27 per cent.

Percentage composition of ash-free deuteromyosinose

							Average
C	50·95	50·98	..			...	50·97
H	7·42	7·42	.	...	....		7·42
N	...		17·00	17·01	....	....	17·00
S	.		...		1·16	1·28	1·22
O	.		...	....	..	..	23·39
							100·00

The ash consisted only of calcium phosphate and sulphate, with some oxide of iron.

This is as far as we have been able at present to carry our study of the myosinoses, since hetero and dysmyosinose appear to have been present in the digestions only in very small quantity. Myosin purified by alcohol, as was the preparation employed by us, is so difficultly digestible that it is attacked only by the most energetic pepsin mixture, and this has the disadvantage of rapidly converting hetero and protoproteose, which according to Neumeister's* investigations are formed in the beginning of digestion, into the deutero body; consequently in the present instance we could expect a large amount only of deuteromyosinose. Corresponding with this view, we obtained for 45 grams of deuteromyosinose, only 10 grams of protomyosinose and but 3 grams of hetero and dysmyosinose. Further, the unavoidable loss attending the separation of these bodies was probably greater with deuteromyosinose than with the others. Portions of the fluid from the first and second digestion, tested before they were united, showed also a difference in that the fluid from the first digestion con-

* Loc. cit.

tained far more proto and dysmyosinose than the latter, which, on the other hand, was particularly rich in deuteromyosinose. From this it is evident how an albuminous body can in one sense be difficultly digestible, in that its solution takes place slowly and its primary cleavage products form gradually, and yet the latter be further transformed, under the continued action of the ferment, far more readily and completely. Our conception of digestibility needs therefore to be broadened, after having for so long embraced simply the time required for solution of the proteid, or, in the case of pepsin digestion, the hardly attainable extreme of complete conversion into peptone.

On comparing now the results of the analyses of myosin and the two myosinoses in the following table,

	C	H	N	S	O
Myosin	52·79	7·12	16·86	1·26	21·97
Protomyosinose .	52·43	7·17	16·92	1·32	22·16
Deuteromyosinose	50·79	7·42	17·00	1·22	23·39

there is seen to be only a small difference in composition between myosin and protomyosinose. The content of carbon in the latter is only 0·36 per cent. less than in the former, that of nitrogen 0·06 per cent. greater and oxygen only 0·17 per cent. greater. Between deuteromyosinose and the undigested proteid, on the other hand, there is a far greater difference in composition, the content of carbon being 1·82 per cent. less, while nitrogen is 0·14 per cent. greater and oxygen 1·42 per cent. greater. In hydrogen, both myosinoses show a small increase over myosin, while the content of sulphur is practically unaltered.

That portion of the myosin, which was apparently not further alterable by gastric juice, together with the somewhat large neutralization precipitate, we attempted to digest by the action of trypsin. This was only partially successful, for although the trypsin solution consisted of an extract from 20 grams of dry pancreas in 2 litres of 0·4 per cent. sodium carbonate, and the proteid matter was warmed with it at 40° C. for six days, we were not able to bring more than half of the material into solution. The digestive fluid behaved somewhat peculiarly, in that with a certain excess of acetic acid it gave a fine pulverulent white precipitate. After removal of this substance, the solution gave no turbidity whatever with sodium chloride, or with sodium chloride and nitric acid, and only a very slight one with ammonium sulphate; hence it contained no myosinoses. Peptone, however, was formed in considerable quantity.

IX.—The Relative Absorption of Nickel and Cobalt. By R. H. Chittenden and Charles Norris, Jr., Ph.B.

When nickel and cobalt were first discovered they were supposed to be possessed of decided toxic properties, and nickel particularly was looked on as more poisonous than copper. Examination, however, of many of the supposed cases of nickel poisoning led to the view that toxic action was due, mainly at least, to the presence of arsenical impurities, with which German nickel particularly was known to be contaminated. Gradually, therefore, the view has become widespread that nickel and cobalt are no more poisonous than iron, with which chemically they are so closely related. We have not, however, been able to find many very definite statements regarding their physiological or toxic action. Blake * in his study of the relation between isomorphism, molecular weight, and physiological action, places the sulphates of nickel and cobalt in the same group with copper, zinc, iron, etc., and further arranges cobalt, copper and zinc together in a sub-group, on account of their arresting the action of the heart and preventing the coagulation of the blood. Nickel, however, is placed with manganese on account of its exerting a marked influence on the nervous system. As to the intensity of their physiological action, Blake apparently considers nickel and copper of the same strength, while cobalt is figured as one-twentieth stronger. Both salts, however, kill by arresting the action of the heart and in lethal action cobalt stands first.† Woodman and Tidy ‡ state that 30 grains of the oxide of cobalt given to a dog proved fatal in a few hours, whilst 3 grains of the sulphate injected into a vein proved fatal in four days. With nickel, the same writers state that vomiting is freely induced in a dog by a dose of 20 grains of the sulphate, whilst 10 grains injected into the jugular vein will destroy life instantly. Finally, Brunton and Cash have found that nickel and cobalt, like most other metallic salts, cause slight contraction of the blood vessels.§

* American Journal of Science and Arts, vol. vii, p 194.

† See Brunton's Pharmacology and Therapeutics, p. 51.

‡ Forensic Medicine and Toxicology, p. 171 and p. 214.

§ Brunton's Pharmacology, p. 246.

Our experiments have been conducted wholly upon rabbits, the main object being to study the distribution of the absorbed poison. The salts used were chemically pure cobalt and nickel nitrates, dried over sulphuric acid. They were administered by mouth in gelatin capsules.

We first endeavored to gain some idea of the relative toxic action of the two salts. For this purpose two rabbits, weighing 2 kilos. each, were dosed as follows :

Experiment I.

			Rabbit A.			Rabbit B.		
Oct.	1,	10 a.m.	0·150	gram	$Ni(NO_3)_2$	0·150	gram	$CO(NO_3)_2$
"	1,	4 p.m.	0·102	"	"	0·100	"	"
"	2,	10 a.m.	0·150	"	"	0·150	"	"
"	2,	5 p.m.	0·101	"	"	0·100	"	"
"	3,	9 a.m.	0·200	"	"	0·200	"	"
"	3,	4 p.m.	0·200	"	"	0·200	"	"
"	4,	9 a.m.	0·251	"	"	0·250	"	"
"	4,	5 p.m.	0·250	"	"	0·250	"	"
"	5,	10 a.m.	0·350	"	"	0·350	"	"
"	5,	4 p.m.	0·350	"	"	0·350	"	"
"	6,	9 a.m.	0·500	"	"	0·500	"	"
"	6,	8 p.m.	0·500	"	"	0·500	"	"
			3·104 grams.			3·100 grams.		

Both rabbits died on the morning of the 7th, apparently from heart failure. The urine was examined each day, but in both cases was entirely free from either sugar or albumin. On the 3d, the cobalt rabbit appeared troubled with involuntary micturition and defecation, and on the 5th there was quite pronounced partial paralysis of the hind quarters. The appetite remained good up to the 6th. On the 6th instant, after administration of 500 milligrams of the cobalt salt, there was a loose diarrhœa continuous till death, decided paralysis of the hind legs, total loss of appetite with a decided lowering of the body temperature. After death, the body weight was found to have diminished three-fifths of a kilo. With the nickel rabbit, there was no diarrhœa whatever and the paralysis of the hind legs, visible on the 6th, was not as pronounced as with cobalt. The loss of body weight was the same as in the cobalt rabbit.

On post-mortem, the only noticeable abnormal feature with either cobalt or nickel was a slight congestion of the lining membrane of the stomach and intestines. The stomach, however, was found full of undigested food, as if the salt had interfered with the digestive process.

It is thus seen that neither the cobalt or nickel salt can be called a violent poison, since comparatively large amounts are required to produce a toxic effect, and even then the action is somewhat slow. This is still more clearly seen in the next experiment.

Experiment II, with cobalt.

A vigorous black doe, weighing 2 kilos., was dosed as follows:

Oct. 8,	0·200	gram	cobalt	nitrate.
" 9,	0·400	"	"	"
" 10,	0·600	"	"	"
" 11,	0·700	"	"	"
" 12,	0·250	"	"	"
" 13,	0·250	"	"	"
" 14.	0·250	"	"	"
" 15,	0·550	"	"	"
" 16,	1·000	"	"	"
" 17,	1·500	"	"	"
" 18,	2·000	"	"	"
	7·700 grams.			

The animal died on the 19th, of heart failure. On the 11th, when 7 decigrams of the salt were given, the animal appeared sickly, with loss of appetite, high rectal temperature, etc., but by diminishing the dose of cobalt the animal rapidly recovered. On the 17th, however, with increase in the dose of salt there was diarrhœa, with a slight indication of paralysis of the extremities. At no time did the urine contain either sugar or albumin. There was a decided loss of body weight, nearly one-third. On post-mortem, the stomach and small intestines were found somewhat inflamed, and the liver showed signs of a slight fatty degeneration.

Immediately on the death of the animal the internal organs were removed and the absorbed cobalt determined.

The method of analysis, both for cobalt and nickel, was as follows: The finely divided tissue was oxidized with dilute hydrochloric acid and potassium chlorate, after the usual method. From the solution so obtained, chlorine was removed by evaporation, the fluid made alkaline with ammonia and the cobalt or nickel precipitated by a stream of hydrogen sulphide gas. The washed sulphide, after ignition, was then dissolved in nitro-hydrochloric acid, the free acid entirely removed by heat and the chloride converted into sulphate by addition of concentrated sulphuric acid. Ultimately, the sulphuric acid solution of sulphate was diluted somewhat with water, made strongly alkaline with ammonia and the metal separated by electrolysis.

Following are the amounts of absorbed cobalt found in experiment II:

	Total weight of organ. grams.	Weight of Co milligrams.	Co per 100 grams of tissue. milligrams.
Stomach and contents	81·75	57·5	70·34
Small intestines	43·90	13·8	31·44
Large intestines	26·40	40·2	152 10
Cæcum	154·00	302·5	196·43
Liver	45·75	8·9	19·43
Kidneys	10·30	lost	...
Heart	8·80	0·7	7·95
Lungs	5·82	0·9	15·46
Muscle of legs	100·00	1·9	1·90
Muscle of back	27·45	1·5	5·46
Brain	8·75	0·8	6·45
Spinal cord	3·63		

Considering the large amount of cobalt nitrate administered, the extreme solubility of the salt, and the length of time intervening between the first and last dose, it is somewhat surprising that the amount absorbed was not greater. Evidently a large portion of the cobalt passes directly through the alimentary canal, probably combining with the proteid matter of the food to form an insoluble and indigestible compound.

Experiment III, with nickel.

A black and white doe of 4 kilos. body weight was dosed as follows:

Oct. 15,	0·200	gram nickel nitrate.
" 16,	0·400	" " "
" 17,	0·600	" " "
" 18,	0·800	" " "
" 19,	0·500	" " "
	2·500	grams.

On the morning of the 20th, the animal was found dead, the only noticeable symptoms having been general weakness, loss of appetite and diarrhœa. The loss of body weight was quite pronounced, amounting in the six days to 1·4 kilos. The urine was entirely free from albumin and sugar. There was a little inflammation of the stomach. In this experiment, the toxic action would appear to have been greater than that of the cobalt in the preceding experiment. The distribution of the absorbed poison was as follows:

	Total weight of organ. grams.	Weight of Ni. milligrams.	Ni per 100 grams of tissue. milligrams.
Stomach and contents.. ..	115·00	12·2	10·68
Small intestines....	67·87	11·4	16·88
Large intestines	87·45	8·9	10·41
Cæcum....	190·00	9·4	4·95
Liver	87 50	5·1	5·88
Kidneys	18 85	0·8	4·24
Heart.... .	8 90	1·3	14·60
Lungs	14 15	0·9	6·36
Muscle of legs	292·00	1·2	0·41
Muscle of back	129 00	3·8	2·95
Brain....	8·75	2 1	24·00
Spinal cord	5 00	1·0	20·00
Spleen..	2·00	0·6	30·00

The amount of nickel found in the alimentary tract is naturally not so large as in the case of cobalt, where the final doses were larger and the diarrhœa not so bad. Of the absorbed nickel, the distribution is essentially the same as with cobalt. The amount in the kidneys and liver is not as large as would be expected from the size of the doses and the soluble character of the salt. It suggests that only a small portion of the salt given is absorbed, and that elimination goes on with comparative slowness. Quite striking is the peculiar distribution of the nickel in the muscle tissue, the amount in the muscles from the back being seven times as large as in the leg muscles. The same peculiarity is likewise noticeable with cobalt. Also noticeable is the comparatively large amount in the brain and spinal cord, more of the poison in proportion to the weight of the organ being found here than in either the liver or kidneys.

Experiment IV, with cobalt and nickel.

In this experiment, two rabbits of approximately the same body weight were dosed with nickel and cobalt respectively as follows :

	Rabbit A.	*Rabbit B.*
Nov. 1,	0·200 gram $CO(NO_3)_2$.	0·200 gram $Ni(NO_3)_2$.
" 2,	0·150 " "	0·350 " "
" 3,	0·250 " "	0·200 " "
" 4,	0·400 " "	0·300 " "
" 5,	0·250 " "	0·500 " "
" 6,	0·800 " "	0·800 " "
" 7,	0·500 " "	0·800 " "
" 8,	0 " "	0·500 " "
	2·550 grams.	3·150 grams.

Both animals were found dead on the 9th. In the cobalt rabbit, the stomach, lungs, kidneys and brain were found more or less congested and there was considerable diarrhœa before death. In the nickel rabbit, there was no diarrhœa and but little congestion. Rectum was found full of hard fæces.

Following is the distribution of the poison in the two rabbits.

Rabbit A, cobalt.

	Total weight of organ. grams.	Weight of Co. milligrams.	Co per 100 grams of tissue. milligrams.
Stomach and contents	76·65	10·8	14·09
Small intestines	58·70	7·5	12·77
Large intestines	20·10	10·9	54·23
Cæcum	108·00	50·5	46·76
Liver	91·08	8·3	3·62
Kidneys	13·55	0·8	5·90
Heart	13·37	0·9	6·73
Lungs	9·62	1·3	13·50
Muscle of legs	196·00	1·2	0·61
Muscle of back	95·85	1·7	1·77
Brain	8·87	1·2	13·53
Spinal cord	4·95	0·9	18·18

Rabbit B, nickel.

	Total weight of organ. grams.	Weight of Ni. milligrams.	Ni per 100 grams of tissue. milligrams.
Stomach and contents	64·80	18·4	28·39
Small intestines	52·30	2·0	3·82
Large intestines	12·10	2·0	16·53
Liver	70·00	5·6	8·00
Kidneys	11·20	0·8	7·05
Heart	6·72	0·8	11·90
Lungs	7·92	2·1	26·51
Muscle of leg	157·00	1·1	0·70
Muscle of back	82·00	2·0	2·44
Brain	9·00	1·2	13·33
Spinal cord	3·98	1·7	42·71

Very noticeable in both of these results, as in the preceding experiments, is the comparatively large amount of poison in the brain and spinal cord, also the same relative distribution in the muscle tissue of the legs and back previously commented upon. The large amount of poison in the lungs and heart, as contrasted with the liver and kidneys, is also quite noticeable.

Experiment V, with nickel.

In this experiment, 1·8 grams of nickel nitrate were given by mouth during five days to a rabbit of 1·5 kilos weight, the individual doses being of about the same size as in preceding experiments. On the sixth day, the animal died of heart failure. Following is the distribution of the poison.

	Total weight of organ grams	Weight of Ni milligrams	Ni per 100 grams of tissue milligrams
Stomach and contents	78·00	3·2	4·38
Small intestines	59·10	1·8	3·04
Large intestines	36·40	9·9	27·20
Cæcum . .	176·00	36·5+	20·74+
Liver ..	58·00	8·1	13·96
Kidneys .	10·27	0·8	7·79
Heart .	7·42	1·3	16·63
Lungs	6·52	0·2	3·06
Muscle of legs . .	97·30	2·6	2·67
Muscle of back .	35·00	3·7	10·57

Experiment VI, with cobalt.

In this experiment, an attempt was made to ascertain something regarding the elimination of the cobalt through the kidneys. For this purpose, the urine was collected each day and the cobalt determined by the same method as used in the analysis of the organs. The rabbit (body weight 2·5 kilos.) was dosed as follows:

		Examination of the 24 hours' urine
Nov. 27,	0·100 gram $Co(NO_3)_2$	30 c.c. contained 1·8 milligrams Co
" 28,	0·200 " "	50 " " 6·1 " "
" 29,	0 "	78 " " 6·2 " "
" 30,	0·300 " "	
Dec. 1,	0·200 " "	
" 2,	0 " "	120 " " 23·8 " "
" 3,	0·400 " "	
" 4,	0·400 " "	
" 5,	0·400 " "	
" 6,	0·400 " "	
" 7,	0·400 " "	
" 8,	0·500 " "	
" 9,	0 " "	
" 10,	0·500 " "	
" 11,	0·500 " "	
	4·300 grams.	

The animal died on the 12th. On the last day, 15 c. c. of thick, dark brown, viscid urine were voided which contained 1·8 milligrams of cobalt. 7·15 grams of fæces excreted during the last 24 hours were found to contain about 100 milligrams of cobalt. Obviously a large amount of the cobalt passes directly through the alimentary canal, while of the absorbed portion considerable is eliminated through the urine, much more indeed than the small amounts found in the kidneys would appear to warrant.

On analysis of the organs of this rabbit, the following results were obtained:

	Total weight of organ grams	Weight of Co milligrams	Co per 100 grams of tissue, milligrams
Liver	66·00	2·6	3·94
Spleen	0·40	0·5	125·00
Kidneys	15·30	0·5	3·27
Heart	10·73	0·1	0·93
Lungs	7·02	1·0	14·24
Muscle of leg	140·00	9·8	7·00
Muscle of back	130·00	4·7	3·61
Brain	8·35	1·5	17·96
Spinal cord	4·10	2·0	48·78

Here, as in many of the preceding cases, the lungs contain a higher percentage of the poison than either the liver or kidneys, while the brain and spinal cord contain a still higher percentage.

With this rabbit, convulsions were noticed shortly before death and the breathing was very labored, as if the respiratory muscles were affected.

An experiment, similar to the preceding, tried with nickel, led to a like result as regards the elimination of the poison. The first 24 hours' urine (25 c. c.) contained 1·6 milligrams of nickel, while the portion (70 c. c.) passed during the 24 hours preceding death contained 8·1 milligrams of the metal. Further, 3·5 grams of fæces excreted during the last 24 hours contained 17·5 milligrams of nickel.

It is obvious from the foregoing that soluble nickel and cobalt salts are possessed of decided toxic properties, but that their poisonous action is somewhat slow and manifested only when comparatively large amounts of the salts are administered. Further, so far as our experiments show, the two salts act very much alike. Both apparently cause death by stopping the action of the heart and also produce more or less disturbance in the alimentary tract, interfering with digestion, producing more or less inflammation of the mucous

membrane of the stomach and intestines, and causing a more or less persistent diarrhœa. Unlike uranium, these salts have no apparent action on the kidneys or liver, sections of hardened tissue from these organs showing no change of structure. Further, in every case the urine of the poisoned animal was entirely free from sugar and albumin throughout the experiment Both salts tend to produce a partial paralysis of the extremities, more pronounced possibly with cobalt than with nickel. They enter the circulation quickly, are rapidly distributed to all parts of the body and are in turn more or less rapidly eliminated by the kidneys. Considerable, however, evidently passes directly through the alimentary tract and is excreted through the fæces.

Both salts appear to raise the internal body temperature quite decidedly, the rectal temperature rising even two or three degrees centigrade. The blood vessels of the ears, on the contrary, quickly become constricted under the influence of the salts, and the ears appear white and quite cold.

The storage power of the individual organs is somewhat peculiar. The spinal cord and brain, in the majority of the experiments, stand first in their power of picking up and retaining the nickel and cobalt. This is in close accord with what has already been found with soluble forms of arsenic,* and more recently with strychnine sulphate.† It would have been interesting in this connection to have seen whether, as with arsenic, the form of the poison modifies the relative amount absorbed by the brain and spinal cord, but this we did not have time to try. Again, as with soluble forms of arsenic, the muscle tissue shows in several of the experiments, as Nos. V and VI, a marked affinity for nickel and cobalt, retaining a larger percentage of the metals than either the liver or kidneys. Still more noticeable, in all of the experiments but one, is the much larger amount of poison in the muscles of the back than in the muscles of the leg; a constant difference occurring in a tissue of the same kind, and hardly explainable on the ground of difference in vascularity. A somewhat similar distribution of arsenic in the muscle tissue was found by one of us a few years ago in an arsenical poison case.‡

* Chittenden, Amer Chem Journal, vol. v, p. 8, also Studies from Laboratory of Physiological Chemistry, vol I, p 141 Scolosuboff, Bulletin de la Société Chimique de Paris, vol xxiv, p 125

† R. W Lovett, Journal of Physiology, vol IX, p. 99

‡ Chittenden, Amer. Chem. Journal, vol v, p 12

Another striking feature in the storage of nickel and cobalt by the tissues, is the comparatively large amount retained by the lungs and heart, the amount found in these organs generally exceeding the amounts stored up in the liver and kidneys.

X.—RESULTS OBTAINED BY ETCHING A SPHERE AND CRYSTALS OF QUARTZ WITH HYDROFLUORIC ACID. BY DR. OTTO MEYER AND SAMUEL L. PENFIELD.

A few years ago one of us* published the results of an experiment of etching a sphere of calcite with acetic acid in which the symmetry of a calcite crystal was brought out by the character of the etchings on the sphere and the final result of eating away the greater part of the calcite was a crystalline figure with rounded faces, but with a decided steep scalenohedral habit with truncations at the extremities of the vertical axis. This suggested to us the idea of trying similar experiments on spheres cut from other crystals. The difficulty of course lies in obtaining spheres of perfectly pure homogeneous material; the results furnish, however, an interesting and instructive means of studying the symmetry of any crystalline substance and as parts of the sphere are parallel to all possible faces of a crystal, as soon as the relation of the sphere to the axes of the crystal is made out the character of the etchings in any particular part of the sphere will determine the character of the etching produced by the solvent on any crystal face parallel to that particular part of the sphere. The ease with which spheres of Japanese quartz can be obtained and the readiness with which quartz yields in certain directions, to the action of hydrofluoric acid, made the following experiments quite easy, while the results as will be seen are far more striking than one would at first suppose.

The results of our experiments will be better understood by reviewing some experiments made in 1855 by F. Leydolt† on quartz crystals in which he showed that hydrofluoric acid acts very unequally on the different kinds of faces, so that not only the right and left-handed character of the crystals, but also all the complexity of twinning can be made to appear by etching. The experiments were repeated by us by placing simple quartz crystals from Herkimer, N. Y., in strong hydrofluoric acid and leaving them till sufficiently distinct etchings were produced. In these experiments, some of which were carried on in cold and some in hot acid, the character of

* Meyer, Jahrb. Min., 1883, i, 74.

† Sitz-ber. der Wiener Akad., 1855, xv, p. 59.

the etching was in all cases the same, and as quartz is dissolved by the acid very slowly it is not probable that slight changes in the temperature or strength of the acid would have made any appreciable difference. On the ordinary quartz combination of prism, *m*, I, $10\bar{1}0$, positive rhombohedron *r*, 1, $10\bar{1}1$ and negative rhombohedron *z*,−1, $01\bar{1}1$ the following etchings are very easily developed. The positive rhombohedron *r* yields most readily to the action of the acid becoming covered with elongated unsymmetrical depressions having a horizontal direction, the heaviest part being to the right in a right handed crystal, fig. 1, plate I, and to the left in a left handed crystal fig. 2, plate I. The top and middle edges of these depressions are nearly straight, the bottom slightly curved, the widest end is terminated by a straight edge having the direction of the zonal edge between *r* and the adjacent *z* face. These etchings are distributed thickly over the *r* faces, and although they are not all exactly alike, their general character is well represented in figs. 1 and 2. The effect of this action is also to eat away and replace all of the edges of the crystal toward which the heaviest ends of the etchings are turned; thus in a right-handed crystal between *r* and *r* ($10\bar{1}1$ and $\bar{1}101$), *r* and *z* ($10\bar{1}1$ and 0111) and *r* and *m* ($10\bar{1}1$ and $01\bar{1}0$) all to the right, while the corresponding edges to the left toward which the points of the depressions on *r* are turned, are left perfectly sharp, except of course the upper parts where *r*, $10\bar{1}1$ forms a short edge with the adjacent *r*, 0111 face to the left. In a left-handed crystal, this same phenomena can be observed only with the corresponding edges eaten away to the left instead of to the right. This replacement of the edges is not shown in figs. 1 and 2, but is shown in the original figures of Leydolt, who also determined the symbols of the faces replacing the different edges. According to our experience the replacement of the edges appears more like an accumulation of little facets, all reflecting the light simultaneously, than a replacement made by a single face and for a discussion of the symbols of the faces and the determination of the twinning structure of quartz as shown by the etchings we refer our readers to the original paper of Leydolt. If the crystals are left in the acid for a sufficiently long time the edges between the rhombohedron faces become so far eaten away that nothing is left of the original rhombohedron faces and the prism is left terminated by the etching faces alone, which flatten out the crystal very much in the direction of the vertical axis.

On the negative rhombohedron *z*, the etchings are of an entirely different character, composed of a system of shallow depressions

with curved contours, giving a sort of feather-like marking with the direction of greatest action turned toward the heaviest etching on the positive rhombohedron, figs. 1 and 2, plate I.*

The prismatic faces are much less acted upon than the rhombohedron faces, the etchings varying somewhat in character but consisting essentially of four sided depressions with long and short vertical edges parallel to the edges of the prism, one straight steep edge on the side of the positive rhombohedron *r* and parallel to the zonal edge between *m* and *z*, and a shorter slightly curved edge on the side of the negative rhombohedron *z*. These etchings have definite relations to the symmetry of the crystals and are of reverse character on right, fig. 1, plate I, and left, fig 2, plate I, handed crystals. On adjacent prismatic faces, the longer or shorter vertical edges are turned toward each other, and by prolonged etching the alternating prismatic edges, toward which the shorter vertical edges of the etchings are directed, are slightly eaten away while the other prismatic edges remain sharp and perfect.

From a consideration of the above we can now more readily understand the action of hydrofluoric acid on a sphere cut from a simple quartz crystal. A sphere of about 2·44 c. m diameter was purchased in New York, and etched by placing it in a lead crucible containing rather a strong commercial hydrofluoric acid, such as can be bought in rubber bottles from dealers in chemicals. The exact strength of the acid was not determined. No special care was taken to place the sphere in any particular position in the acid, its position being accidentally changed nearly every day when the acid was removed, and the solution of the quartz going on so slowly that the acid had a chance to act apparently equally on all similar parts of the sphere. During the progress of the etching, which was carried on slowly in the cold, photographs of the etched sphere were obtained at three stages, which seemed well suited for illustration.

* According to my experience these etchings on the rhombohedron faces furnish one of the best methods of showing to a beginner in crystallography that the six faces which usually terminate a quartz crystal, are not the faces of an hexagonal pyramid, and all alike, but are those of a positive and negative rhombohedron To prepare sections for showing this with a microscope, crystals should be etched till the markings are sufficiently distinct, then by cementing the crystal, with the etched face down, to a glass plate with Canada balsam and cementing glass plates on either side, the quartz can be ground away with emery till the glass plates form a large wearing surface and the quartz is ground to just the thickness of the glass plates, then after removing the slice of quartz and cleaning it it can be cemented to an object glass with the etched surface up and is ready for examination with the microscope —Penfield.

After leaving the sphere in the acid for a few hours, the etchings were distinctly observed and their arrangement on the sphere was such that its crystalline nature and relation to hexagonal axes could be determined. The location of the extremities of the vertical axis was marked by the centers of two triangular patches on opposite sides of the sphere, while the character and arrangement of the prominent etchings on the positive rhombohedron indicated the right handed character of the crystal from which the sphere was cut as well as the location of the extremities of the lateral axes. After being in the acid for about four days some of the etchings were very prominent, and the sphere had the appearance represented in figures 1 and 2, plate II. In figure 1 we are looking down upon the sphere in the direction of the vertical axis. In the centre there is a distinct, somewhat hexagonal field, the center of which marks the extremity of the vertical axis. This whole portion is one where the etching has gone on very vigorously, and with the microscope it can be seen that the surface is composed of minute triangular pyramids grouped closely together. About this, three prominent parts, which are arranged in the alternating sections of the hexagon, indicate the position of the positive rhombohedron by the greater extent of the etching, leaving very distinct prominences with their steep sides turned to the right. A distinct ridge or marking, from which the lines of etching go off very distinctly, can also be seen about in the center of each negative rhombohedron. In fig. 2, we are looking at the sphere about at right angles to a prismatic face. A little above the center of the figure and trending to the right, the prominent etchings, indicating the position of the positive rhombohedron, can be seen, while below and to the right they can also be seen in the position of the lower positive rhombohedron. On what may be called the equator of the sphere, midway between the above mentioned prominent etchings on the positive rhombohedrons above and below, the extremity of one of the lateral axes can be located a little to the right of the center of the figure. On much of the surface near the equator of the sphere, the original polish has not been destroyed. The vigorous action of the acid at the extremities of the vertical axis is plainly seen accompanied already by a slight flattening of the sphere.

After exposing the sphere again to the action of the acid for about two weeks it had the appearance represented in figures 3 and 4, plate II. In figure 3, where we are looking down upon the sphere in the direction of the vertical axis, three parts on the equator, located by

the right hand and upper and lower left hand angles of the hexagon, indicate one extremity of each of the three lateral axes and from these parts the lines of etching run out very beautifully toward the center and the prominent marking on the rhombohedron faces. In figure 4, where we are looking at right angles to the vertical axis, besides the decided flattening, a rhombic portion, about in the center of the field, is conspicuous, the center of which locates the extremity of one of the lateral axes. On this portion not only could the original curved surface of the sphere be detected but also the original polish. The acid having had apparently no action on this portion of the sphere, while the etched portions come up to meet this with sharp and distinct angles. Owing to a slight misunderstanding a mistake was made in photographing figure 4, which was not discovered till it was too late to correct it. If we imagine the sphere turned 90° so that the unattacked portion would appear at the right and seen at a tangent, while one of the two similar portions which are now behind and out of sight would appear in the front and a little to the left, the quartz would appear in just the right position to compare with figures 2 and 6. As it is we are looking at the crystal not at right angles to a prism *m* but at right angles to a prism of the second order $\bar{1}2\bar{1}0$

By exposing the quartz for about one month longer to the action of the acid it appeared as represented in figures 5 and 6, plate II. In figure 5, which is again a vertical view, we can readily locate the extremities of the three lateral axes by the right hand and upper and lower left hand angles of the hexagon. At these parts the curved contour of the sphere is preserved for a short distance, but between them there is a decided tendency toward a triangular cross section. The sphere as will be seen from figure 6 has become extremely flattened and the upper and lower portions meet along a very sharply defined line. The etchings seem to arrange themselves along parallel lines or ridges and some idea of their beautiful arrangement can be obtained from the larger reproduction shown in figure 3, plate I. In figure 6 we notice, in addition to the extreme flattening, two of the three portions where the acid has had very little action, one taken at a tangent to the right, the other a little to the left of the center; these appear as very conspicuous parallelograms; they have a curved surface similar to that of the original sphere, and although the original polish has disappeared from them only the finest etchings can be detected with the microscope. It can almost be said that the acid has had no action on these three surfaces, at least not enough to

destroy the original polish of the sphere till toward the very end of the experiment and not enough to appreciably diminish the diameter of the sphere. Although the original diameter was not accurately measured care was taken soon after commencing the etching to cut a hole in a card board very carefully just large enough to allow the sphere to pass and at the conclusion of the etching the quartz just touched at these three points when passed through the same hole.

The quartz was still exposed to the action of this acid for about a week, but the general effect was not different from that shown in figures 5 and 6. Of course the sphere was still further flattened in the direction of the vertical axis and the three parts at the extremities of the lateral axes where the acid had acted least, became considerably changed, being flattened out more in a vertical direction and therefore appearing as parallelograms, relatively much more elongated horizontally. Figure 3, plate I, is from a photograph taken at this stage in which the relation of these parts to the longer sharp edge between them is less than in figure 5, plate II. At this stage also the etching of the sphere was stopped and the specimen deposited in the collection of Professor George J. Brush, New Haven, Conn.

In review it will be noticed, as is the case in all etching, that the acid acts very unequally on different faces of a crystal and therefore on different parts of the sphere, equally, however, on those similar parts of the sphere which are similarly situated with reference to hexagonal axes. The action is greatest at the two extremities of the vertical axis. The action seems to be, especially toward the end, to lift off or dissolve away layers of molecules from above and below while there are three parts, which are each one of the ends of three lateral axes, where the acid exerts practically no solvent action. These parts diminish in size as the action of the acid continues but not by any action of the acid upon them directly, except as the molecules were taken away from above, below and at the sides. This is one of the most striking features of the experiment that in these three directions quartz is almost absolutely insoluble in hydrofluoric acid. As a study in symmetry the experiment all along was a very interesting one. The etched sphere could never be divided by a plane into symmetrical halves and showed throughout all of the experiment the tetratohedral character of a right-handed quartz crystal. The sphere was cut from a crystal which would have shown etchings like those in figure 1, plate I. The accompanying illustrations give only a faint idea of the beauty of the etched sphere, it

being impossible to reproduce the delicacy and beauty of the markings as they appeared on the perfectly transparent material of the quartz.

Pyro-electrical experiments.—To further test the relation of the sphere to crystallographic axes, it was heated for some hours in an air bath to 100° C. and on cooling dusted with a mixture of red oxide of lead and sulphur, according to the excellent method described by Professor A. Kundt of Strassburg.* The red oxide of lead and yellow sulphur arranged themselves in six alternating vertical bands about the equator of the sphere, the red bands being located midway between the heaviest parts of the etchings on the positive rhombohedrons above and below. On the etched sphere represented in figure 2, plate II, a red band ran vertically a little to the right of the center, a yellow one a little to the left of the center and so on, three red alternating with three yellow about the equator of the sphere. On the etched sphere represented in figures 5 and 6, plate II, the slightly attacked parallelogram parts, representing the ends of the lateral axes, were yellow while the center of the sharp edges midway between them were red. These pyro-electrical phenomena, according to B. von Kolenko,† indicate that the crystals from which our sphere was cut was a right-handed one; that part of the sphere where negative electricity develops on cooling and where the positively electrified red oxide of lead deposits, indicating the position of the prismatic edge, where the right-handed trapezohedral faces above and below would occur. The even distribution of the pyro-electricity into six alternating positive and negative sections prove the simple character of the sphere and the absence of twinning. This latter was very important for the success of our experiment, for if the sphere had been cut from a complicated twin crystal the etchings would have arranged themselves in a very confused manner, and the shapes produced by the etching would have been very much modified.

In closing we wish to express our thanks to Mr. J. M. Blake of New Haven, for the care which he took in photographing such a difficult, transparent object, and to Mr. E. Bierstadt of New York, for the pains which he took in the preparation of the plates.

Mineralogical Laboratory, Sheffield Scientific School, Feb. 4th, 1889

* Ann. d. Phys. u. Chem., 1883, xx, p. 592.

† Zeitsch. f. Kryst., ix, 1884, p. 1.

EXPLANATION OF PLATES.

Plate I.

1 Etchings produced on the faces of a right handed quartz crystal by hydrofluoric acid

2 Etchings produced on the faces of a left handed quartz crystal by hydrofluoric acid

3 Final result of eating away the greater part of a sphere (cut from a right handed quartz crystal) with hydrofluoric acid during a period of about eight weeks Seen in the direction of the vertical axis The angles of the hexagon mark the extremities of the lateral axes

Plate II

1 and 2 Appearance of the etched sphere after being in the acid about four days 1 Seen in the direction of the vertical axis 2 Seen in the direction at right angles to the vertical axis and a prism of the first order

3 and 4 Appearance of the etched sphere after being in the acid about three weeks 3 Seen as in 1 4 Owing to a mistake in taking the photograph seen about at right angles to a prism of the second order

5 and 6 Appearance of the etched sphere after being in the acid about seven weeks 5 Seen as in 1 and 3 6 Seen as in 2

XI.—New England Spiders of the Families Drassidæ, Agalenidæ and Dysderidæ. By J. H. Emerton.

Drassidæ.

The *Drassidæ* have long bodies like the *Agalenidæ* and *Lycosidæ*, but most of them are a little flattened above and walk with their bodies near the ground; the first and second feet are directed forward and the third and fourth backward. The feet have but two claws, under which is usually a cluster of hairs sometimes so thick as to conceal the claws. The under sides of the tarsus and metatarsus are sometimes covered with hairs, especially on the first and second legs, and these hairs are often flattened or thickened at the end. The cephalothorax is low in front, the highest part being in the middle or farther back. The eyes are in two nearly straight rows. The spinnerets are cylindrical with the tubes on the end, and the upper and under pairs are nearly equal in length.

None of the *Drassidæ* make webs for catching insects, though many of them make nests, usually flattened tubes, in which they hide in winter or while moulting or laying eggs. Most of them live on the ground and hide under leaves and stones. A few, as *Clubiona*, *Chiracanthium*, and *Anyphæna* live in summer on plants several feet above the ground.

Many species are found adult at all seasons and probably live several years.

The cocoons are flat, some are attached by one side, but most of them lie loose in the nest or hiding place.

A large number of American species were described and figured by Hentz, most of them under the generic name *Herpyllus*. Of these I have identified nine: *H. descriptus*, *crocatus*, *alarius*, *ecclesiasticus*, *ater*, *bilineatus*, *variegatus*, and *Clubiona saltabunda*, *pallens*. Several others have been described by Thorell, and of these I have identified *Gnaphosa brumalis* Thor., Proc. Boston Soc. Nat. Hist., vol. xvii, 1875, and *Gnaphosa conspersa*, *G. scudderi*, and *Prosthesima melancholia* Thor., Bulletin Hayden's U. S. Geol. Survey, vol. iii, No. 2, 1877. The specimens of this family in the Museum of Comparative Zoology in Cambridge, Mass., have been named by Keyserling, and I have adopted his names for several species though they are not yet published.

Micaria Westring

This genus was first separated from *Drassus* by C. Koch under the name of *Macaria*, which had before been used for a genus of *Lepidoptera*, and was therefore changed by Westring to *Micaria* in 1851. They are all small and slender spiders with the cephalothorax arched upward in the middle, without any dorsal groove or only a thick opaque spot in place of it. The abdomen and usually the cephalothorax are covered with flattened scales sometimes brightly colored and iridescent. The tarsus and metatarsus of the first and second feet have a double row of flattened hairs on the under side.

Hentz's *Herpyllus auratus*, found farther south, belongs to this genus and is nearly related to *M. longipes*.

Micaria longipes, new sp.

PLATE III, FIGURES 1*a*, 1*b*, 1*c*, 1*d*, 1*e*, 1*f*, 1*h*

Largest specimen 5^{mm} long. Pl. III, fig. 1. The cephalothorax is twice as long as wide, widest across the middle. Head not much narrowed. The eyes occupy half the width of the head. The front row is nearly straight, the upper row with the middle eyes highest. Eyes all nearly of the same size. The cephalothorax is highest in the middle, curving downward toward both ends. The abdomen is one-half longer than the cephalothorax and about as wide, blunt at both ends and drawn in a little at the sides and above about one-third its length from the front. The legs are long and slender, the fourth pair longest. The colors are light yellowish brown with gray hairs and scales which have green and red metallic reflections on the abdomen. The legs are darker from before backward, the front pair all light yellow except the femur, and the fourth and third pairs with longitudinal brown stripes that nearly cover the tarsal joints. The cephalothorax is without markings. The abdomen has a pair of white stripes at the constricted spot and a less distinct pair near the front end. At the hinder end it is almost black. The scales of the abdomen are of various forms, those of the white spot are long with several branches at the base figs. 1*d*, 1*e*, those of the front of the abdomen are more simple, fig. 1*c*, and those behind the white markings are half as wide as long with two rows of short branches fig. 1*f* at some distance from their edges. The under side of the abdomen is as dark as the upper side. The white markings extend under half way to the middle line. The sternum is nearly twice as long as wide, widest at the second pair of legs and narrowed to a point behind.

The maxillæ are a little notched on the outer sides and straight on the ends except at the inner corners. The labium is two-thirds as long as the maxillæ. It is narrowed toward the tip, where it is about half as wide as at the base, fig. 1*a*.

The male palpi are small, the patella and tibia are about of the same length; at the base of the tibia on the upper side is a large tooth nearly as long as the diameter of the palpus, and curved strongly forward, fig 1*b*. The tarsus is as long as the tibia and patella together, and pointed at the end. The palpal organ is small, fig. 1*b*.

The epigynum of a female from Salem, Mass., appears as in fig. 1*h* with two oblique openings near the posterior edge.

Salem and Medford, Mass., under stones and leaves Adult male in August and adult female in June.

Micaria montana, new sp

Plate III, figures 2, 2*a*

This is smaller than the common species A female measures 4^{mm} long. The cephalothorax is not twice as long as wide and the widest part is behind the middle. The abdomen is twice as long as wide, not constricted or truncated at either end The cephalothorax and legs are light yellow-brown, the legs lighter toward the ends. The abdomen is greenish brown with iridescent scales. Across the middle is a distinct narrow white line and a less distinct one crosses the front of the abdomen. On the hinder half of the abdomen are four or five white spots. The white markings extend a short way under the abdomen. The epigynum, Plate III, fig. 2*a*, has two oblique openings near the posterior edge turned more toward each other and less downward than in *Micaria longipes*

Mt. Washington, N. H., July 1, 1874, east side, near the Ledge.

Geotrecha, new genus

This genus includes a number of American spiders described by Hentz, under the name of *Herpyllus*. Besides *Herpyllus descriptus* and *crocatus*, *H. ornatus*, *H. longipalpus*, *H. marmoratus*, *H. cruciger*, *H. conarius*, *H. trilineatus*, probably belong in it. *H. descriptus* and *H. crocatus* were placed by Koch in the genus *Agrœca*, with which they agree in the shape of the maxillæ and position of the eyes. In this, he was followed by Keyserling, who named the specimens of that species in the Museum of Comparative Zoology, in Cambridge, Mass., *Agrœca crocata*. In the same collec-

tion another species, *Geotrecha bivittata*, is named by Keyserling *Castianeira bivittata*, the genus *Castianeira* having been named by Keyserling, in 1879, for a South American spider, with a long, slender cephalothorax and a slender abdomen with the front part hardened and differently colored from the softer part.

In our species of *Geotrecha*, the cephalothorax is about two-thirds as wide as long and narrowed in front, more in some species than in others. The abdomen is longer and a little wider than the cephalothorax. It sometimes has a small, hard patch at the front end which is of the same color as the rest of the back and not easily seen. The abdomen is round, not flattened above as it usually is in *Prosthesima*. The legs are long and slender. The hairs on the under side of the first and second legs are only slightly flattened and thickened, and the claws concealed by a thick bunch of hairs. The maxillæ are nearly straight as in *Agrœca* and the labium is as short as wide. The eyes are close together in the middle of the front of the head, the front row nearly straight and the hind row with the middle eyes highest. The middle eyes of both rows are largest and farther apart than they are from the lateral eyes. The spinnerets are very small and close together. The colors are dark brown and black, with white or bright colored markings.

The male palpi have the patella and tibia both short and the tarsus long and tapering. The palpal organ is round at the base and tapers to a fine point. The epigynum has two simple openings directed backward, and differing in size and distance apart in different species.

Geotrecha bivittata.

Castianeira bivittata Keyserling, specimens in Cambridge Museum

PLATE III, FIGURES 3*a*, 3*b*, 3*c*, 3*d*

Length, 7 or 8^{mm}. Legs of fourth pair, 10 or 11^{mm}. The cephalothorax is widest across the middle in front of the dorsal groove, Plate III, fig. 3*a*, and is about half as wide at either the front or hinder end. The abdomen is usually about as long as the cephalothorax and widest at the hinder third. It is sometimes slightly drawn in at the sides and above over the front white marking. This is caused by contraction in alcohol, the front end of the abdomen being hardest contracts less than that part just behind it. The legs are long and tapering, the fourth pair longest.

The cephalothorax is dark brown. The abdomen is of the same color, a little lighter, with two white cross stripes, one about the middle of the back and the other, a less distinct one, farther for-

ward. The femora of all the legs are striped lengthwise with brown and yellow. The hind legs are brown with a little yellow on the upper side of the patella and tibia. The other legs are yellow, sometimes with brown stripes on the under side. The white marks on the abdomen extend underneath half way to the middle line. The front hard part of the under side of the abdomen is lighter than the hinder part, and the sternum is of the same color. The coxæ are lighter yellowish brown.

The epigynum shows through the skin as three dark spots and has two openings directed backward, fig. 3*d*.

The male palpi have the patella very short, about half as long as the tibia, fig. 3*b*. The tarsus is very large and dark colored, wide at the base and tapering toward the tip. The palpal organ is similarly shaped, with a rounded bulb through which the coiled tube can be seen, and a slender tip lying in a groove in the tarsus, fig. 3*c*.

Hentz's *Herpyllus zonarius* and *trilineatus* seem to be near this species.

It lives under leaves at all seasons of the year, and though not so quick in its motions as *crocata* is a difficult spider to catch except in cold weather, when it is often sifted from leaves in a torpid condition.

Massachusetts, Connecticut, and in N. Pike's Long Island collection.

The color is sometimes lighter, the whole cephalothorax above and below being light orange color, and the legs the same color, with the longitudinal brown stripes very narrow and indistinct.

In young individuals of both varieties the sternum is wider and more convex than in adults.

Geotrecha pinnata, new sp

PLATE III, FIGURES 4, 4*a*

The largest specimen is 7^{mm} long, cephalothorax, 3^{mm}.

The cephalothorax is shaped much as in *C. crocata.* The abdomen is oval, not so much narrowed in front as in the other species.

The cephalothorax is light brown. The abdomen is grayish brown with several white transverse stripes. The two widest stripes are in the same position as the two stripes of *C. bivittata.* On the front of the abdomen is another stripe, and on the posterior half are four or five others, some of them incomplete on the middle of the back. The femora of all the legs are light brown, the first, second and third legs are yellow, except the femora. The fourth legs have the tarsus and the ends of the tibia yellow, the rest light brown. Plate III, fig. 4.

Epigynum, like that of *crocata*, but with the holes larger and nearer together, fig. 4*a*.

The palpal organs and male palpi resemble those of *crocata*, but are a little larger.

Three specimens, of different ages, from Medford, Mass., under leaves with *C. bivittata*. Three adult females from Topsfield, Mass., Sept. 3d, under log in woods. Males and females in N. Pike's Long Island collection.

Geotrecha crocata.

Agræca crocata Keys., specimens in Mus. Comp. Zool., Cambridge, Mass.

♀ *Herpyllus descriptus* Hentz.

♂ *Herpyllus crocatus* Hentz.

PLATE III, FIGURES 3*b*, 3*c*, 3*d*.

Length of female, 8 to 10^{mm}; cephalothorax, 4^{mm}. The cephalothorax is nearly twice as long as wide and widest across the dorsal groove. It is not narrowed behind as much as in *C. bivittata*. The abdomen is usually longer than the cephalothorax and a little wider at the widest part.

The cephalothorax is very dark brown or black, and the femora and coxæ of all the legs are the same color. The abdomen is black with a bright red spot of variable shape and size at the posterior end. The spot turns yellow in alcohol. In some specimens it is wanting. In the males the red spot is usually larger, sometimes extending the whole length of the abdomen. The hind legs are black or brown their whole length, a little lighter at the ends; the other legs are yellow, except the femora. The under side of the body is all black.

The epigynum has two small round openings, wide apart, a little in front of the transverse fold. Plate III, fig. 3*d*.

The male palpi are much like those of *C. bivittata*, but the tarsus and palpal organ are only about half as large and the patella and tibia are nearly equal in length. The tibia has a short process on the under side. Figs. 3*b*, 3*c*.

This spider lives among stones in dry, open places. It is easily alarmed and moves very rapidly. The flat, parchment-like cocoons common on stones in pastures are probably made by this species.

Massachusetts and Connecticut, and in N. Pike's Long Island collection.

Prosthesima L. Koch.

Cephalothorax widest in the middle and more than half as wide in front. Eyes near together, occupying about half the width of the head. The middle eyes of both rows smaller than the lateral and nearer together than they are to the lateral eyes. Upper row straight, or the lateral eyes a little farther back. Sternum large and nearly as wide as long. Maxillæ wide in the middle and but little widened at the ends, Pl. III, fig. 6*a*. First and second legs with flattened hairs under the tarsus and part of the metatarsus.

Prosthesima atra.

Herpyllus ater Hentz

Prosthesima funesta Keyserling, specimens in Mus Comp. Zool., Cambridge, Mass

Prosthesima melancholica Thorell, Bull Hayden's U. S. Geol Survey, Vol. III, 1877

PLATE III FIGURES 6, 6*c*, 6*d*

Female, 8mm long ; cephalothorax, 3mm. Male smaller. Cephalothorax and abdomen both a little flattened above. Cephalothorax narrow in front, about half as wide as in the middle. Plate III, fig. 6. Abdomen oval, the hinder half usually a little wider than the front. Sternum very large, almost as wide as long, fig. 6*a*. Maxillæ and labium large and a little shorter and wider than in *P. ecclesiastica.* Feet 1 and 2 with flattened hairs under the tarsus and half the metatarsus. Feet 3 and 4 with fine hairs in the same places.

The whole body is black in most individuals, sometimes, especially in the young, yellowish brown on the ends of the feet and under the abdomen.

Epigynum large and distinct with two small depressions in front and large openings behind surrounded by a thick brown rim, fig. 6*d*.

The male palpus is short with a very large tarsus, as long as the tibia and patella together and more than half as wide. The process on the outside of the tibia is about as long as the tibia itself and nearly straight. The palpal organ has a small fine tube and several small hooks and processes all at the tip end of the palpus, fig. 6c.

This spider lives under stones and leaves. The cocoon is flat on one side, by which it is attached, and convex on the other. It is white, or sometimes a little pink.

Mt. Washington, N. H., Eastport, Me., Massachusetts, and in N. Pike's Long Island, N. Y., collection.

P. melancholica was found by Dr. A. S. Packard at Monitou, Colorado, 1875.

Prosthesima depressa, new sp

PLATE III, FIGURES 8, 8*a*.

A smaller species than *atra*. Female, 6^{mm} long. The head is much smaller than in *atra* and the eyes larger and closer together. Plate III, fig. 8. The cephalothorax and abdomen are black. The first and second legs have the tarsus and metatarsus pale yellow, the rest of the legs black except a pale spot on the outside of each femur. The third and fourth legs have the tarsus and metatarsus pale, the tibia black at the distal end, the leg becoming lighter from this point to the base. Underneath, the coxæ are darker from behind forward.

The epigynum has the openings at the sides, farther forward, and the ridges over them thicker and shorter than in *atra*, and the two little depressions in front appear to be wanting, fig. 8*a*.

Medford, Mass., July 23.

Prosthesima ecclesiastica.

Prosthesima propinqua Keys.
Herpyllus ecclesiasticus Hentz

PLATE III, FIGURE 7, 7*a*, 7*b*, 7*c*, 7*d*.

This spider is about 8 or 10^{mm} long, a little smaller than *Gnaphosa conspersa* which it resembles in form and habits, but from which it is easily distinguished by its colors. The cephalothorax is black at the sides and has a whitish stripe in the middle. The abdomen is black at the sides with a bright white stripe in the middle that extends from the front end about two-thirds its length. At the hind end of the abdomen, just over the spinnerets, is another white spot. The legs are dull black turning to brown in alcohol, as does the cephalothorax. The under side of the abdomen is dark at the sides and light in the middle.

The eyes cover about half the width of the head, The two rows are nearly equal in length, the hinder only a little the longer. Seen from above, both rows appear straight. Pl. III, fig. 7.

The maxillæ are widened at the end, the outer corner sharp and the inner rounded off down to the lip. Fig. 7*a*.

The male is much smaller than the female but similarly marked. The male palpi are small. The patella and tibia are short, and the tarsus is as long as both together. The process on the tibia is slender and about equals the tibia in length. It is on the outer side, showing indistinctly from above. It is slightly forked at the tip. The

palpal organ is simple, with two short processes on the outer end. Fig. 7*c*, 7*d*.

The epigynum has a small oval opening at the posterior end of a dark area. Fig. 7*b*.

Under stones. Boston, Salem, Danvers, Wood's Holl, Mass.; Albany, N. Y.; Providence, R. I.

Pœcilochroa Westr, Simon

PLATE IV, FIGURES 1*a*, 3*a*

The cephalothorax is narrowed toward the front, as in *Prosthesima,* and more narrowed in males than in females. The two rows of eyes are far apart, the hinder row a little longer than the front row, with the lateral eyes farther back than the middle ones. The middle eyes are farther apart than they are from the lateral eyes. The labium is not much longer than wide and a little narrowed toward the end. The maxillæ are about twice as long as the labium. They are narrower at the base and widen to the insertion of the palpi. From the palpi the maxillæ curve inward and nearly meet in front of the lip. The outer corners are turned outward. Pl. IV, figs. 1*a*, 3*a*. The colors are bright and the markings distinct.

Pœcilochroa variegata.

Herpyllus variegatus Hentz.

Drassus variegatus Keyserling, specimens in Mus Comp Zool, Cambridge, Mass.

PLATE IV, FIGURES 1 1*b*, 1*c*

This is one of the most distinct and brightly colored species of the family. Pl IV, fig. 1. The cephalothorax is bright orange, a little darker toward the eyes. The abdomen is black with three white transverse stripes from the middle of which a T-shaped white mark extends half way to the front stripe. On the front half of the abdomen the white stripes are usually partly colored with orange. The femora of the first and second legs are black. The distal end of the femur and both ends of the tibia of the fourth legs are black. The legs are otherwise orange colored. The hinder row of eyes is considerably longer than the front row, the rear lateral eyes being their diameter nearer the sides of the head than those of the front row. The head of the male is much narrower than that of the female. The male palpus has a process on the outer side of the tibia half as long as the tarsus, tapering toward the end and slightly bent inward at the tip. The tube ends near the outer end of the tarsus and is supported by a short thick process. Figs. 1*b*, 1*c*.

This spider is common under leaves in dry woods. Eastern Massachusetts; Dublin, N. H.; New Haven, Conn.

Pœcilochroa montana, new sp

PLATE IV, FIGURES 2, 2*a*

This species is a little larger and less brightly colored than *P. variegata.* Pl. IV, fig. 2. Female 8^{mm} long, cephalothorax 3.5^{mm}. The arrangement of the eyes and proportions of the body are about the same. The cephalothorax and legs are dark brown, the hinder ones a little the lighter. The abdomen is black with a pair of white spots near the front end and another pair across the middle nearly united in the middle. The sternum and coxæ are dark brown. The epigynum is dark brown with a small opening at the hind end. Fig. 2*a*.

Mt. Washington, N. H., on the road to Gorham.

Pœcilochroa bilineata.

Herpyllus bilineatus Hentz

PLATE IV, FIGURE 3, 3*a*

A very distinct species on account of its markings. Cephalothorax white, with two black stripes and a fine black line on the edge, each side. Pl. IV, fig. 3. Abdomen thickly covered with long hairs, white in the middle and at the sides, and with two wide black stripes that do not extend quite to the end. The under side of the abdomen is white with a black stripe each side. Fig. 3*a*. The legs are covered with gray and white hairs.

The female is 7^{mm} long, cephalothorax 3^{mm}. The head is about half as wide as the middle of the thorax. The eyes are small, the middle pair in each row farther apart than they are from the lateral eyes. The two rows are widely separated. Sternum oval, widest in the middle. Spinnerets long. Epigynum small, with a single opening directed backward just in front of the transverse fold.

Gnaphosa Latr, 1804.

Gnaphosa brumalis Thorell, Proc. Boston Soc. Nat Hist., vol. XVII, 1875.

Gnaphosa scudderi Thorell, Bull. Hayden's U. S Geol Survey, vol III, 1877.

PLATE IV, FIGURES 5, 5*a*, 5*b*

This species is a little smaller than *G. conspersa.* A female of the usual size is 10^{mm} long, cephalothorax 4^{mm}, while *conspersa* grows to the length of 12 or 15^{mm}.

The colors are the same as those of *conspersa;* cephalothorax and legs dark brown and abdomen rusty black

The epigynum has the openings rather wider apart, and the front middle appendage flat, wrinkled at the edges, and with a hard spot in which is a small hole near the end. This appendage resembles the finger in the same position in *Epeira* Pl. IV, fig. *5b.*

The male palpus has the tibia rather shorter and its outer process longer than in *conspersa*, fig. 5. The tube of the palpal organ is only about half as long, its base being nearer the middle of the tarsus. The middle hooked appendage is as long as in *conspersa*, but much more slender, fig. *5a.*

Under stones on Mt. Washington, N. H., from the ledge upward, with cocoons of eggs July 1.

Males and females from Ellis Bay, Anticosti, July 23, S. Henshaw in collection of Boston Soc. Nat. Hist.; females with cocoons of eggs.

The specimen named by Thorell was from Strawberry Harbor, Labrador, collected by A. S. Packard in 1864.

G. scudderi was found by A. S. Packard at the Garden of the Gods, Colorado, in 1875.

Gnaphosa conspersa Thorell, Bull. Hayden's U S Geol. Survey, vol iii, 1877

Gnaphosa gigantea Keyserling, specimens in Mus. Comp Zool., Cambridge, Mass.

PLATE IV, FIGURES 4, *4a*, *4b*, *4c*, *4d*, *4e*.

This spider is 12 to 15^{mm} long and rusty black in color. Some specimens freshly moulted are dull yellowish or greenish gray, and old individuals have a brownish color. The whole body and the legs are covered with long hairs. The cephalothorax is wide in front and the eyes are not so close together as in *Pythonissa imbecilla*, or in *Prosthesima.* The hinder row of eyes is a little longer than the front row, and the lateral eyes are larger and farther back than the middle ones. Pl. IV, fig. 4. The middle hinder eyes are a little oval and oblique, diverging toward the front. The mandibles are large and strong, on the inner side under the claw they have a wide flat tooth with irregular and serrated edge, and near the inner corner two large pointed teeth, fig. *4b.* The maxillæ are very wide and curve inward so as nearly to meet around the end of the lip. Their outer corners are rounded, fig. *4a.* The spinnerets are stout and the lower pair are widely separated. The male differs but little from the female. The male palpi have the patella and tarsus both short and the

tarsus as long as both of them. The tibia has a short pointed process extending forward over the tarsus, fig. 4*c*. The tarsus is curved outward at the end. The tube of the palpal organ is slender and extends along the outer edge of the tarsus for its whole length. At the outer end of the palpal organ is a short process flat at the end and curved downward, fig. 4*d*. The epigynum has a long opening on each side and a short transverse pit in front of them in the middle, fig. 4*e*. In western specimens the opening at the hinder part of the epigynum has the sides more nearly parallel, not diverging forward as much as in those from New England.

It lives under stones and leaves. The cocoon is white and flat, with its diameter as great or greater than the length of the spider. The female stays near the cocoon, but makes no nest.

All over New England, from the White Mountains, N. H., to New Haven, Connecticut; Adirondacks, N. Y.

Thorell's specimens were collected by A. S. Packard in 1875. A female with cocoon of eggs on Gray's Peak, Colorado, over 11,000 feet high, on fir, Kelso's cabin, Colorado, and a small one from Idaho, all adult females and all smaller than most eastern specimens.

Pythonissa Koch.

Pythonissa imbecilla Keyserling, specimen from Kentucky in Mus Comp Zool., Cambridge, Mass

PLATE IV, FIGURES 6*a*, 6*b*, 6*c*, 6*d*

The male is about 4^{mm} long and the female 5^{mm}. The two rows of eyes are nearly of the same length, the hinder row almost straight, with the lateral eyes only slightly farther back than the middle ones. The lateral eyes of both rows are larger than the middle eyes. The maxillæ are almost as wide as long and are curved inward so as to touch in front of the lip. Pl. IV, fig. 6*a*. The front edge of the maxillæ is straight with the corners only slightly rounded. The mandibles are small and the wide tooth under the claw, fig. 6*b*, can be plainly seen just in front of the maxillæ with another pointed tooth on its inner side. The cephalothorax, both above and below, and the legs are orange-brown with black hairs. The abdomen is bluish black with a few whitish hairs at the hind end and around the four muscular spots near the middle. The epigynum, as in fig. 6*d*. The patella and tibia of the male palpus are very short and not so thick as the femur. The tarsus is as long as the patella and tibia together. The palpal organ is large and complicated, the tube showing plainly across the outer end, fig. 6*c*.

Under stones. Males from Dublin, N. H., and Dedham, Mass. Females from Bluehill, Milton, Mass.

Drassus.

PLATE IV, FIGURE 7*a*

The genus *Drassus* of Walckenaer included the greater part of the present family *Drassidæ*, as well as some *Agalenidæ* and *Ciniflonidæ*. From this, various genera have been separated from time to time, leaving the present *Drassus* an ill defined group containing species differing greatly among themselves and forming several groups, which further study will no doubt make it possible to separate. The only two species which I place in this genus belong, one near the European *D. lapidosus* and the other near *D. troglodytes*. In these species the cephalothorax is wider in front and less flattened than in *Gnaphosa* and *Prosthesima*. The eyes are small and separated by spaces at least as wide as their diameter. The front row is nearly straight. The posterior row is longer, and curved with the lateral eyes lower than the middle. The middle hinder eyes are oval and turned apart toward the front, and are nearer together than to the lateral eyes. The mandibles and maxillæ are large and stout. The maxillæ are widened on both sides beyond the insertion of the palpi, the outer corners are slightly rounded and the inner corners slope obliquely toward the lip. Pl. IV, fig. 7 *a*. The lip is about half as long as the maxillæ. The colors are gray and drab with fine short, white or gray hairs, and only faint markings on the abdomen.

Drassus saccatus, new sp.

PLATE IV, FIGURES 7, 7*c*, 7*d*

This is one of the most common of our *Drassidæ*. Pl. IV, fig. 7. The female grows to be 12^{mm} long, with legs 10^{mm} to 15^{mm}. The color is light gray sometimes with indistinct transverse dark markings on the abdomen. The color of the front part of the head is a little darker and the feet and mandibles and maxillæ are brown. The abdomen is long and slender as in *Clubiona*. The epigynum is small and has two dark round depressions just in front of the fold, fig. 7*d*.

The male is smaller and more slender. The male palpi are very long the patella, and tibia are together as long as the femur, and all are as long as the femur of the first legs. The tibia has a small process on the outer side, fig. 7*c*. The tarsus is long and narrow,

and the palpal organ is small with a short tube near the distal end, fig. 7*c*.

These spiders live under stones in a large bag of silk in which the female stays with her cocoon of eggs. In the early summer a male and female live together in the nest, the female often being immature.

White Mountains, N. H., to Connecticut.

Drassus robustus, new sp.

PLATE IV, FIGURES 8, 8*a*, 8*b*, 8*c*

This is a smaller and shorter legged species than the preceding. Pl. IV, fig. 8. The female is 8^{mm} long. The colors are darker and redder, especially toward the head. The sternum, maxillæ and mandibles are dark brown. The head is as wide as in *D. saccatus*, and the eyes are a little closer. The epigynum is large, light colored in the middle, and with a dark ridge each side, fig. 8*a*. The male is much smaller than the female. The palpal organs and tarsi are large and round. The tarsus is short and has a short curved process that extends over the tarsus on the upper side, fig 8*b*, 8*c*.

Medford, Mass., July.

Clubiona Latr

Cephalothorax very wide in front. Front row of eyes straight, or with the middle pair a little higher than the lateral, nearly equal in size and equidistant, or the middle a little larger or farther apart than they are from the lateral. Upper line of eyes longer and slightly curved with the middle pair highest, the eyes all larger than those of the front row, and the middle pair usually farthest apart. Plate V, fig. 8*e*. Maxillæ long, narrow at the base, and much widened beyond the insertion of the palpi. Fig. 10. The mandibles are stout and convex at the base in the females. In the males the mandibles are more slender, longer and tapering at the tips, sometimes with sharp ridges along the sides. Legs slender, the fourth pair longest. Feet with long claws, the first and second pairs with the under side of tarsus and metatarsus covered thickly with hairs widened at the end. The abdomen is truncated in front and tapering behind. The colors are always pale gray and drab, usually with darker brown on the head around the eyes, and rarely a light brown or gray pattern on the back of the abdomen. The body is covered with short and fine hairs which give it a soft silky appearance without concealing the color of the skin.

Most species vary greatly in size, some mature individuals being twice as large as others of the same age and sex. They live on plants in summer, and in winter hide under bark or stones, and have at all seasons flat tubular nests of silk.

Clubiona crassipalpis Keyserling, specimens in Mus. Comp. Zool., Cambridge, Mass.

PLATE V, FIGURES 1, 1*a*, 1*b*.

Male 8^{mm} long, sometimes smaller. Cephalothorax two-thirds as wide as long. Male mandibles convex in front for two-thirds their length, with a low ridge along the inner side and around the end of the convex portion. The thin keel on the front outer edge is sharp but short, extending only a little over the convex part.

The tibia of the male palpus is as long as the patella. The process on the outer side is long and slender, the end curved inward over the tarsus. Plate v, figs. 1, 1*a*, 1*b*.

Abdomen marked with brown irregular veins, the rest of the body pale. Head a little darker toward the front.

Massachusetts, Connecticut, Albany, N. Y., Providence, R. I., and in N. Pike's Long Island collection.

Clubiona mixta, new sp.

PLATE V, FIGURES 2*a*, 2*b*.

Resembles *C. crassipalpis* and of about the same size. The mandibles of the male are similarly shaped, but the convexity and the internal ridge are less prominent. The male palpi are a little more slender and the patella proportionally longer. The process of the tibia has the upper tooth nearer the hook than in *crassipalpis*, making the process appear wider and stouter, fig. 2. The tarsus is a little smaller than in *crassipalpis*. Plate v, figs. 2*a*, 2*b*.

Salem and Marblehead, Mass.

Clubiona tibialis, new sp.

PLATE V, FIGURES 3, 3*a*, 3*b*.

Male 6·5^{mm} long, another 5^{mm} long. The male mandibles are slender and tapering, without any distinct ridges on the front. The male palpi are short and the tibia and tarsus both very large. The tibia is very complicated in shape, having a large hook on the outer side, a short thick process on the inner side, and a thickened edge in front that meets a slight elevation on the back of the tarsus. The tarsus is long and large, and so is the palpal organ. Plate v, figs. 3, 3*a*,

A female, apparently of this species, is 6mm long. The front legs are shorter than in the male; the mandibles are stout and convex in front. The epigynum is large with a deep rounded notch in the middle and a slight ridge each side. Fig. 3*b*.

Eastern Massachusetts, and in N. Pike's Long Island collection.

Clubiona canadensis, new sp

PLATE V, FIGURES 4, 4*a*, 4*b*, 4*c*.

Male 7mm long, others smaller. Mandibles tapering and rounded, without ridges on the upper side. Male palpi short, tibia shorter than patella, with a complicated process on the outer side ending in a long sharp point with a round notch in the upper edge. Plate v, figs. 4, 4*a*. The tarsus is more than twice as long as wide, bent downward at the end. The palpal organ has a large bulb with small appendages at the end. Fig. 4*b*.

Female a little larger, epigynum with only two depressed spots just in front of the transverse fold. Fig. 4*c*.

Abdomen dark, with brown irregular lines. Cephalothorax pale, not darkened toward the front.

The common species on Mt. Washington, N. H., from the Glen to the highest trees, under stones and in moss; also from Montreal, Canada.

Clubiona minuta, new sp.

PLATE V, FIGURES 11, 11*a*, 11*b*

This little spider is about 3mm long and in its general appearance resembles a pale *C. rubra*. The male palpi, however, show it plainly to be a different species. The patella is longer than wide, as in *rubra*, and the tibia is short and wide at the end. Its appendage on the outer side is very simple, appearing from above like a thin spine at the side of the tarsus and not overlapping it. Pl. v, fig. 11. From the outer side it is seen to be flat, wide at the base, and tapering from the middle to a blunt point, fig. 11*a*. The palpal organ has a small hook on the inner side, fig. 11*b*, very different from the large hook of *C. rubra*.

Male from Readville, Mass., June 15, on bushes.

Clubiona pusilla, new sp.

PLATE V, FIGURES 5, 5*a*, 5*b*.

One male 6mm long, another only 4mm. Head nearly as wide as the thorax.

Front row of eyes half as long as the head is wide, the eyes of equal size and equidistant; upper row, longer by the diameter of the lateral eyes. The upper eyes are larger than those of the front row, and all about the same size, the middle pair a little farther apart than they are from the lateral eyes.

Mandibles with a thin keel on the front outer edge, half as long as the mandible.

Colors, pale on the legs and palpi; cephalothorax brownish yellow, darkest in front; abdomen covered with fine brown markings.

Male palpi with the tibia shorter than the patella. A flat wide process on the outer side, Pl. v, fig. 5*a*, extends forward over the tarsus. The bulb of the palpal organ nearly fills the under side of the tarsus, the tube is short and curved round the end of the tarsus so as to point backward ; over the base of the tube is a short stout hook, instead of a large hook as in *rubra*, fig. 5.

Salem and Beverly, Mass.

Clubiona rubra Keyserling specimens in Mus Comp Zool, Cambridge, Mass

PLATE V, FIGURES 6, 6*a*, 6*b*, 7, 7*a*, 7*b*, 8, 8*a*, 8*b*

This is one of several closely similar species, the classification of which cannot well be understood without comparing large numbers from many different places. *Clubiona abbottii* L. Koch, is this species or very close to it

Males and females are 3 to 4^{mm} long. The eyes are large in proportion to the size of the spider, and cover the whole width of the front of the head.

The color after keeping in alcohol is redder than in most species.

The epigynum is notched at the hinder edge, the depth of the notch varying in different individuals. Pl. v, figs. 6*c*, 7*c*.

The male palpi have the patella and tibia of the same length. The relative length of these joints differs in the allied species. The tibia is wider than long and has a large appendage on the outer side, divided from the main part of the tibia by a deep notch on the under side, figs. 6, 7, 8. The appendage consists of two parts, figs. 6*a*, 7*a*, 8*a*, the under one longest and a little notched at the end. The size and length of this process varies in different individuals. On the dorsal side of the tibia, on the front edge, is a small tooth, varying in size in different spiders, figs. 6, 7, 8. The palpal organ has a very large middle process, figs. 6*b*, 7*b*, 8*b*.

White Mountains, N. H., to Connecticut.

Clubiona ornata, new sp

PLATE V, FIGURES 9, 9*a*

Female 8mm long. The abdomen is pointed behind and more narrowed in front than in most species. Both abdomen and cephalothorax are less flattened than in most species. The mandibles of the female are not very stout and less swelled at the base than usual.

This is one of the few species with a colored pattern on the abdomen. A dark stripe runs along the middle, of a different width in different individuals, but generally narrow and tapering behind. At the sides of this are two white or light yellow stripes with irregular edges, and beyond this the brown sides of the abdomen. Pl. v, fig. 9. The body is pale underneath. The epigynum is notched at the edge of the transverse fold, fig. 9*a*.

Mt. Washington, Dublin, N. H., and Massachusetts.

Clubiona excepta L Koch

Clubiona pallens Hentz

PLATE V, FIGURES 10, 10*a*, 10*b*, 10*c*, 10*d*

Female 7mm long, cephalothorax 3mm. The abdomen is not usually much larger than the cephalothorax and unlike most species has a pattern on the back similar to that of *Amaurobius* and *Tegenaria*, or in very light individuals consisting of three rows of gray spots on a white or pale yellow ground. Pl. v, fig. 10*a*. The cephalothorax and legs are light yellowish brown, darkest on the head and mandibles. The spinnerets are rather long. The epigynum has two round brown spermathecæ that show through the skin, close together just in front of the transverse fold. In front of these are two oblique openings directed forward and inward.

The males are not much smaller than the females. The male palpi are slender, the tibia only a little longer than the patella, and the tarsus nearly as long as both together. The tarsus is oval, about half as wide as long, and rounded on the upper side. The papal organ is narrow and covered by the tarsus. On the inner side is a thin appendage, the free edge of which lies along the middle line and covers the long straight tube. On the outer side near the end of the tube is a straight process directed forward, and at its base a hook directed backward, fig. 10*c*. At the end of the tibia on the outer side is a short flat process with a small curved tooth on the upper corner, fig. 10*b*.

Massachusetts, Connecticut, and in N. Pike's Long Island collection. Under stones and leaves, sometimes in white cocoons.

Chiracanthium C. Koch

Chiracanthium viride, new sp.

PLATE V, FIGURES 12, 12*a* 12*b* 12*d*

Female 8mm long, cephalothorax 3mm. Cephalothorax three-fourths as wide in front as at the widest part, fig. 12*a*. Eyes spreading over nearly the whole width of the head; the lateral eyes close together; the upper row a little longer than the front row, eyes in both rows at equal distances apart. Abdomen widest in the middle, tapering behind. First pair of legs a third longer than the fourth. Sternum widest just behind the first pair of legs and tapering to a point between the fourth coxae. The mandibles and maxillæ are dark brown. The rest of the body is pale yellow, the cephalothorax a little darker than the rest, and a gray stripe covers the middle of the front of the abdomen. The epigynum has a large oval opening covered by a hard dark brown lump. Pl. v, fig. 12*d*.

In the male the mandibles and legs are longer and the difference in length between the first and fourth legs is greater. The palpi are as long as the second femur. The tibia is twice as long as the patella, and has on the outer side a thin black process, a little curved toward the tarsus, and on the upper side a thick blunt process extending a little way over the back of the tarsus. Between the two processes of the tibia a sharp process of the tarsus extends backward, a little curved down at the end, figs. 12*a*, 12*b*.

Female, Dedham, Mass., July 26. Male, Saugus, Mass., June 12.

Trachelas L. Koch

Trachelas ruber Keyserling.

PLATE V, FIGURES 13, 13*a*, 13*c*, 13*d*.

Female 10mm long, cephalothorax 4mm long and 3mm wide. The cephalothorax is widest in the middle opposite the second pair of legs and narrows to 2mm at the hinder end, the sides of the hinder half being nearly straight. The head is very wide and high, the highest part half way between the eyes and the dorsal groove.

The eyes are all about the same size and far apart. The front row is nearly straight, the middle eyes a little higher than the lateral, this row is half as long as the head is wide. The hinder row is much longer, the middle eyes are about as far from the front middle pair as they are from each other, the lateral eyes are about the same distance from the middle ones, but much farther back on the head, figure 13. The mandibles and maxillæ are large and resem-

ble those of *Clubiona.* The abdomen is oval and very regular in shape. Pl. v, fig. 13. The cephalothorax is very thick and hard, and dark brown. The abdomen is light yellow with no markings, except four small brown spots near the middle, and a gray streak over the dorsal vessel. The hairs are very short and scattered so that the skin appears soft and smooth.

The *first pair of legs* is a little the longest instead of the fourth pair, as in the European species, and both the first and second pairs are much stouter than the third and fourth. The palpi are slender, the tarsal joint thickened at the tip. The legs are darker from back to front, the front pair reddish brown, not so dark as the cephalothorax, and the hind pair is yellow. The epigynum has two dark brown round depressions close together.

Pale individuals are sometimes found with all the legs yellowish white, cephalothorax light brown with white eyes, and the abdomen light gray.

The males are smaller than the females, sometimes not more than half as large. The tibia of the palpus is shorter than the patella, and has a short hook on the outer side. The tarsus is small and the bulb of the palpal organ is so large that it extends beyond the tarsus on both sides. The bulb is round and has a distinct tube which rests in a groove of the end of the tarsus, figs. 13*c*, 13*d*.

Under stones and leaves and sometimes on fences in autumn. In general appearance and color it resembles *Dysdera.* Massachusetts and Connecticut, and in N. Pike's Long Island collection.

Anyphæna Sundevall.

PLATE VI, FIGURES 1, 1*a*.

Cephalothorax highest behind. Eyes of the front row equal in size and equidistant, the lateral eyes a little the highest. Upper row of eyes longer than the front row, the middle eyes highest, all of the same size and larger than those of the front row and at equal distances apart. Abdomen widest in the middle and a little pointed behind.

Maxillæ long and widened at the tips but not so much widened as in *Clubiona.*

The opening of the tracheæ is farther forward than in other genera, in some species approaching nearly to the epigynum. Pl. vi, fig. 1*a*.

The colors are pale. The male palpi are large and complicated.

Anyphæna rubra, new sp

PLATE VI, FIGURES 1, 1*a*, 1*b*

Female 8 or 9^{mm} long, cephalothorax 3^{mm} Abdomen half longer than the cephalothorax and about as wide, tapering backward from the middle to the spinnerets, Pl. VI, fig. 1. The cephalothorax and legs are pale yellowish brown. The cephalothorax has two darker longitudinal bands. The abdomen is white or light yellow with two stripes made up of brown or red spots. The mandibles are dark brown. This is the largest and stoutest species.

The epigynum has two large curved openings, turned toward each other, between which is a long depression widened at the front end. The long spermathecæ show through the skin just behind the openings, fig. 1*b*. I have not seen the adult male.

Massachusetts and Connecticut, and in N. Pike's Long Island collection. On plants and under stones.

Anyphæna incerta Keys, specimens in Mus Comp Zool, Cambridge, Mass

PLATE VI, FIGURES 2, 2*a* 2*b*, 2*c*, 2*d*

Female 5^{mm} long, cephalothorax 2^{mm}. The cephalothorax is about a quarter longer than wide, rounded at the sides, and highest in the middle. The front of the head is very low, so that the front eyes are not their diameter from the base of the mandibles The front row of eyes is nearly straight. The upper row is longer and more curved, with the middle eyes highest, and the eyes of this row are all larger than those of the front row. The abdomen is large in the female, as in all the species of this genus, widest just behind the middle and a little pointed behind, Pl. VI, fig. 2.

The color is light brownish yellow with gray markings. The cephalothorax has two indistinct longitudinal stripes and a fine black line over the legs on each side. On the abdomen are two rows of faint spots and oblique lines. The legs have a few faint markings across the joints.

The maxillæ are straight at the sides and rounded at the ends on the inner side. The labium is small and not half as long as the maxillæ.

The epigynum has a large dark brown process in the middle at the front end, fig. 2*d*.

The tibia of the male palpus has a large double process on the outer side, the upper branch of which is pointed, and the lower blunt with a rounded tooth on the upper side, figs. 2*a*, 2*b*, 2*c*.

Under leaves in winter. Salem and Swampscott, Mass.

Anyphæna calcarata, new sp

PLATE VI, FIGURES 3, 3*a*, 3*b*, 3*c*, 3*d*

The same size as *A. incerta*, but lighter colored and with longer legs and longer spines. The front legs are longer than the fourth in both sexes. The markings are the same as in the other species and the spots on the front of the abdomen are more distinct than in the others.

The epigynum has a thin edge extending backward a little over the transverse fold and reaching from one respiratory opening to the other. In the middle is a small hole with a short tooth-like ridge directed backward on each side. Pl. VI, fig. 3*d*.

The male palpi have the outer half of the femur twice as thick as the base with a few large spines on the upper side near the end. The patella is as wide as long and shorter than the tibia. The appendage on the outer side of the tibia is very small and does not extend forward beyond the base of the tarsus, fig. 3*b*, 3*c*; near the base of the tibia on the under side is a blunt tooth, fig. 3*a*, 3*c*. The tarsus resembles that of *A. incerta*. The palpal organ has the middle process very stout and curved inward at the end, fig. 3*a*.

The coxæ of the fourth pair of legs have on the under side a small pointed process directed outward. The coxæ of the third pair have on the under side a curved process directed inward with a short tooth on the hinder side near the middle, and in front of this a short blunt tooth directed backward, fig. 3.

West Haven, Conn., July, on plants, and in N. Pike's Long Island collection.

Anyphæna saltabunda.

Clubiona saltabunda Hentz.

PLATE VI, FIGURES 4, 4*a*, 4*b*, 4*c*, 4*d*.

This is a very long-legged and slender species. The female is 4^{mm} long, the abdomen but little longer than the cephalothorax. The front leg is 10^{mm} long, fourth leg 7^{mm}. The palpi are slender and as long as the femora of the first legs. The whole body is white with two broken gray bands on the cephalothorax and two rows of gray spots on the abdomen.

The male is about as large as the female. The male palpi are long, the tibia of very complicated shape. It is curved outward and has near the base on the outer side a long, thin forked process Pl. VI, fig. 4. The tarsus is of the usual shape. The palpal organ has a

short slender tube resting against the tip of the tarsus. Behind the tube is a thin hooked process, and on the inner side a long process with small black teeth at the end, fig 4, 4*a*, 4*b*, 4*c*.

The epigynum has a long transverse opening a little in front of the fold, fig. 4*d*.

Massachusetts, and Meriden, Conn.

Phrurolithus Koch and Westring

Micariosoma Simon

Small spiders sometimes with bright markings and iridescent scales. The legs of the first and second pairs have a double row of strong spines under the tibia and metatarsus. Pl. VI, fig. 5*b*. The maxillæ are short and wide. The palpi of the males are very large compared with the size of the spider, and have a long stout process on the outer side of the tibia. The arrangement of the eyes and the pattern of the dorsal markings resemble those of *Agroeca*.

Phrurolithus pugnatus, new sp

PLATE VI, FIGURES 6, 6*a*, 6*b*, 6*c*

2^{mm} to 3^{mm} long. Cephalothorax round, narrowed at the head as in *alarius*. Abdomen usually shorter and rounder than in *alarius*. Pl. VI, fig. 6. Cephalothorax and legs bright yellowish brown. Abdomen dark brown with transverse light markings which vary in different individuals. Light yellowish beneath, except around the spinnerets and epigynum.

Epigynum with two oblique openings at the front end farthest from the transverse fold. Parts of the palpal organ are sometimes found in the openings of the epigynum, fig. 6*e*.

The male palpi are large in proportion to the size of the spider. The femur has a short process near the base on the inner side. The patella is as short as wide, but the tibia is nearly as large as the tarsus and wider at the distal end. On its inner side is a long stout tooth projecting forward, and on the outer side a longer curved one as in *P. alarius*. The tibia is oval and the palpal organ short and round, not extending backward at the base as in *alarius*, figs. 6*a*, 6*b*.

Herpyllus parcus Hentz resembles this species.

Massachusetts and Connecticut.

Phrurolithus alarius.

Herpyllus alarius Hentz.

PLATE VI, FIGURES 5, *5a*, *5b*, *5d*, *5f*, *5g*, *5h*

Full grown female 4^{mm} long, cephalothorax 1.5^{mm}. Pl. VI, fig. 5.

The cephalothorax is nearly as wide as long, rounded at the sides. The head is about half as wide as the thorax and the eyes are close together and all about the same distance apart, fig. *5a*. The middle eyes of the upper row are oval and turned obliquely, nearest together towards the front.

The abdomen is oval, widest behind, and a little flattened on top. The legs are long and slender, except the tibiæ and metatarsi of the first and second pairs which are twice as thick as the same joints of the other legs, fig. 5. The legs are light yellow or white with gray hairs, except the tibia and patella of the first pair, which are black or dark gray with the tip of the tibia white. The tibia and patella of the second pair are marked with lighter gray in the same way. The tibia and metatarsus of the first and second pairs have two rows of strong black spines on the under side, fig. *5b*.

The cephalothorax is light yellowish with a black edge each side and a few irregular radiating gray marks forming two indistinct longitudinal stripes. The abdomen is gray with transverse white markings which vary greatly in shape and size in different individuals, figs. 5, *5a*. The abdomen is covered with flat branched hairs that are iridescent, changing from light grayish-green to pink with the motions of the spider, fig. *5d*. The under side of the body is pale with a dark mark in front of the spinnerets, and in some individuals a few irregular marks along the sides.

The male palpi are large. The femur is thickened on the under side near the outer end, forming a short black process covered with short stiff hairs. The patella and tibia are both short. The tibia has on the outer side a long process slightly curved downward that extends along the side of the tarsus for half its length, fig. *5g*. The palpal organ is so long that its base extends over the end of the tarsus, fig. *5f*.

The epigynum has two large openings turned toward the sides a little in front of the transverse fold, fig. *5h*.

It lives on and under stones in dry open ground and runs with great swiftness short distances at a time. When still it lies close to the stone with the tibiæ drawn up over the back, as in fig. 5, the thickened and colored legs of the first pair are then the parts of the spider most easily seen.

Massachusetts and Connecticut.

Agrœca Westring.

Agrœca pratensis, new sp.

PLATE VI, FIGURES 7, 7*a* 7*b* 7*c*, 7*d*, 7*e*.

Female 7^{mm} long, cephalothorax 3^{mm}. The cephalothorax is widest and highest behind the middle, the head a little more than half as wide as the thorax. The abdomen is widest across the hinder third and not much pointed behind. Pl. VI, fig 7. The front row of eyes are close together, the middle ones half their diameter highest. The upper eyes are a little larger and about their diameter apart, the middle pair much the highest, fig. 7.

The mandibles are very convex in front and flat at the sides. The maxillæ are straight on both sides and a little rounded on the inner corners. The labium is half as long as the maxillæ and as wide as long. The sternum is large and as wide as long, fig. 7*a*. The legs are stout, the fourth pair longest. Under each metatarsus are three pairs of slender spines, under the first and second tibiæ two pairs, and under the third and fourth tibiæ three pairs. The cephalothorax, legs, and mouth parts are light brownish yellow. The cephalothorax has a fine dark edge on each side and a row of radiating dark lines each side forming two broken dark longitudinal bands. The abdomen has two rows of gray oblique markings on a light ground, fig 7. Epigynum with a long brown piece in the middle, fig 7*e*.

Male about the same size with the abdomen a little smaller. The male palpi are large and stout. The patella and tibiæ are the same length, the latter a little bent and with a short pointed spine on the outer side. The tarsus and palpal organ are short and wide. The palpal organ has a short blunt process on the outer side that projects over the edge of the tarsus, figs. 7*b*, 7*c*, 7*d*.

This spider lives under leaves and in short grass and resembles a *Lycosa* in its gait and general appearance, and also the common *Anyphæna incerta*.

Eastern Massachusetts; Providence, Rhode I.; Albany, New York.

Agalenidæ.

The *Agalenidæ* have the cephalothorax longer than wide, with the cephalic part higher than the thoracic, and distinctly separated from it by grooves or marks at the sides. The head is usually higher than in the *Drassidæ* and the body less flattened. The upper spinnerets are two jointed, the terminal joint pointed and provided with spinning tubes along the inner side. In most species these are longer

than the other spinnerets. The feet have three claws. The *Agalenidæ* make large flat or irregular webs with a tube or hiding place at one side from which they run out and seize the insects that alight on the web. The *Agalenidæ* run on the upper side of the web with their back upward, while *Linyphia*, which makes similar flat webs, runs on the under surface, back downwards.

Cœlotes Blackwall.

The difference between *Cœlotes* and *Tegenaria* is not a very distinct one. I have placed in Cœlotes those stouter and shorter legged species with the mandibles prominent in front, and in which the palpi of the males have processes on both patella and tibia.

The eyes are in two rows, nearly straight, and differ but little in size and distance apart. The mandibles are stout and convex. The maxillæ are wide at the ends, rounded on the outer corners, and obliquely truncated on the inner. The labium is about half as long as the maxillæ, a little narrowed and truncated at the tip. The colors are dark gray and brown.

Cœlotes medicinalis.

Tegenaria medicinalis Hentz.

Plate VII, figures 1*a*, 1*b*

Female 12mm long; cephalothorax 5mm, fourth leg 15mm. Front row of eyes straight, the middle eyes largest, eyes of upper row all of the same size and about equal distances apart, the middle eyes highest. The lateral eyes of both rows are close together, those of the upper row farthest toward the sides. Head high and wide, distinctly separated from the thorax by grooves each side. Abdomen oval, widest behind. Legs moderately stout.

Cephalothorax yellowish brown, darkest in front, marked with radiating gray lines forming two longitudinal dark bands. Abdomen gray with irregular pale spots. A double row of oblique pale spots in the middle, in most specimens broken and irregular, fig. 1 The legs are light yellowish brown with light indistinct gray rings.

The spinnerets are short.

The epigynum has a large piece in the middle with a branch each side that extends outward and forward ending in a point. In front are two small rounded teeth directed inward. Pl. VII, fig. 1*a*.

Male palpus short, with a large and wide tarsus. The patella and tibia are both short and of about the same length. The outer pro-

cess of the patella is half as long as the patella and blunt and crooked at the end. The tibia has on the upper side a short pointed process near the base and a blunt one near the end on the outer side, both concealed by a curved ridge. On the under side of the tibia is a process directed forward. The tube of the palpal organ is slender and supported at the end by two large processes, fig. 1*b*.

Chateaugay Lake, Adirondacks, N. Y., from F. A. Bowditch, 1878; Swampscott, Mass., May 8.

Cœlotes longitarsus, new sp

PLATE VII, FIGURES 2, 2*a*

Male 7mm; cephalothorax 3·5mm. Head wide and high, highest half way between the eyes and the dorsal groove. First leg almost as long as the fourth. Legs stout. Abdomen oval, the hinder half a little the wider. Cephalothorax and legs yellowish brown, a few radiating darker lines on the thorax, and the front of the head a little darker. Legs darker toward the tips. Abdomen dark gray with a median lighter stripe in front and a double row of lighter oblique marks on the hinder half, much as in *medicinalis*.

The patella and tibia of the male palpi are both as short as wide. The patella has a long tooth, widest and truncated at the tip, directed forward on the outer side. The tarsus is widest at the base and pointed at the tip. At the base on the outer side it has a stout process extending backward and inward as far as the patella. Plate VII, fig. 2.

A small female found at the same time and probably the same species has a small, simple oval opening at the posterior part of the epigynum. Fig. 2*a*.

Mt. Carmel, Conn.

Cœlotes montanus, new sp.

PLATE VII, FIGURES 3, 3*a*.

12mm long; cephalothorax 5mm; 4th leg of female 18mm, 4th leg of male 20mm.

Epigynum with the holes open, and oblique turned nearly forward. Plate VII, fig. 3.

Male palpus with short patella and tibia, the tibia shortest. The patella has a short conical, black spine on the outer side near the end, directed forward, under this is a smaller spine. On the outer side of the tibia, which is shorter than the inner side, is a short process turned forward a little at the tip. Fig. 3*a*.

The colors and markings are like those of the two preceding species. The legs, especially of the male, are a little longer in proportion to the size of the body.

Chateaugay Lake, Adirondacks, N. Y., from F. A. Bowditch. A small male from New Haven, Conn., is apparently of this species. Its palpi differ slightly from those of the Adirondack males as shown in figs. 4, 4*a*.

Cœlotes hybridus, new sp.

PLATE VII, FIGURES 4, 4*a*.

This species is only distinguished from *C. longitarsus* by small differences in the shape of the male palpi. The spur at the base of the tarsus is very short and extends backward to a short process on the middle of the tibia. The posterior inner corner of the tarsus is differently shaped from this part in *longitarsus*, having a deep notch shown in figs. 4, 4*a*. The tibia is a little longer than that of *longitarsus* and shaped much like that of *medicinalis*. The patella resembles that of *longitarsus*. In size, markings, and colors this is like both *medicinalis* and *longitarsus*. The palpal organ is almost exactly like that of *longitarsus*.

One male from Chateaugay Lake, Adirondacks, N. Y., from F. A. Bowditch.

Tegenaria Latr

These spiders differ from *Cœlotes* in having the legs longer and more slender and the abdomen generally rounder and shorter. The mandibles are less convex in front, the palpi of the males have no processes on the patella, and the palpal organ is proportionally smaller than in *Cœlotes*.

Tegenaria derhamii Scopoli, 1763; Thorell, 1873.

Tegenaria civilis Blackwall, 1861.
Tegenaria domestica Simon, 1875.

PLATE VII, FIGURES 6, 6*a*, 6*b*, 6*c*.

This is a house spider found all over the world. Female 10^{mm} long; cephalothorax 5^{mm}. Plate VII, fig. 6. The legs are long and tapering, 4th leg 18^{mm} long. Tarsi and metatarsi slender. The head is high and wider in front than it is opposite the first pair of legs. The abdomen is short, only a little longer than the cephalothorax. The front row of eyes is straight, the middle ones smallest. Upper row longer, lateral eyes close to those of the front row, the middle ones much higher, fig. 6.

Cephalothorax and legs light yellowish brown, the legs with some indistinct gray rings. Abdomen pale with gray markings which are usually plainest on the hinder half. The upper spinnerets are twice as long as the lower and the terminal joint is nearly as long as the basal.

Epigynum with small oblique openings at the sides. Fig. 6*c*.

The male palpi have the patella and tibia long and both about the same length. The tibia has on the outer side, about one-fourth its length from the end, a short blunt process, fig. 6*a*, under this is a shorter process lighter colored and directed forward, fig. 6*b*. The tarsus is slender and pointed and the appendages of the palpal organ are small. Figs. 6*a*, 6*b*.

Tegenaria brevis, new sp

PLATE VII, FIGURES 5, 5*a*, 5*b*, 5*c*

A small species, 5 to 6^{mm} long. Cephalothorax two-thirds as wide as long. Abdomen short and widest behind. The mandibles are small and but little convex in front. The cephalothorax and legs are pale yellowish brown with black hairs, the legs and palpi are lightest at the base and darker toward the ends. The spines are very long and slender. The abdomen is in some individuals pale with dark hairs ; in others there is a gray herring bone marking, and gray marks along the sides.

The male palpi are slender and without any appendages on the patella. The tibia has a short stout tooth on the outer side a little behind the end. The tarsus is small and pointed. The palpal organ is round and too large to be covered by the tarsus. Plate VII, fig. 5. The head of the male is narrower than that of the female, and the thorax wider, figs. 5*b*, 5*c*.

The epigynum appears to the naked eye like two parallel dark brown marks. It has a large posterior opening, widest behind, and partly divided into two at the front edge, fig. 5*a*.

The short round abdomen and gray markings make this spider resemble *Steatoda marmorata*.

Mt. Washington. N. H. ; Massachusetts ; New Haven, Conn.

Cicurina Menge, 1871. Simon, 1875.

This genus differs but little from *Cœlotes* except in the palpi of the males which have the patella without processes, the tarsus long and narrow, and the tibia short with a large appendage on the outer side. The tube of the palpal organ is long and supported in various complicated ways.

Cicurina complicata, new sp.

Plate VII, figures 7, 7*a*, 7*b*

This is a small, stout species, the largest individuals measuring 7^{mm} in length, and the cephalothorax 3^{mm}. The cephalothorax, legs, and palpi are uniform yellowish brown. The abdomen is pale with scattered gray markings both above and below, in some individuals forming an indistinct herring-bone pattern on the dorsal side. The sternum is as wide as long and nearly as wide in front as in the middle. The mandibles are stout, and in the females very convex in front. In the males the head is narrower and the mandibles smaller.

The palpi of the males have the patella simple and about as long as wide. The tibia has a short tooth near the base on the outer side, the middle part is turned inward, and on the outer side at the end is a large flat and crooked appendage that in its natural position appears to be part of the palpal organ. Plate VII, fig. 7. In fig. 7*a* the process is shown from the side partly turned away from the palpal organ. The tarsus is long and narrow and rounded at the tip, fig. 7*b*. The tube of the palpal organ is very long, beginning at the base of the tarsus it runs along the inner side around the tip, where it is supported by the edge of a flattened appendage, and backward along the outer side, the end being under the flat tibial process.

The epigynum has a simple oval opening behind, and the tubes show through the skin in light-colored individuals.

Blue hill, Milton, Mass., and Salem, Mass., under leaves, in winter.

Hahnia Koch

Upper eyes all about the same size, the middle pair highest and farthest back and farther from each other than they are from the lateral eyes. Front eyes nearer together, the middle ones highest. The lateral eyes of both rows close together.

The spinnerets are in a single transverse row, the upper pair being outside the others. The outer pair has two nearly equal joints and the next pair have a short second joint at the tip.

The opening of the tracheæ is in the middle of the abdomen instead of directly in front of the spinnerets, as in most of the family.

Small spiders resembling *Tegenaria* and *Cœlotes*, except in the spinnerets.

Hahnia bimaculata, new sp.

PLATE VII, FIGURES 8, 8*a*, to 8*f*.

Length, 2·5mm. Eyes large, both rows with the lateral eyes lowest. Lateral eyes much nearer together than the middle pairs. Front eyes a little the larger, both rows strongly curved, the middle eyes highest. Maxillæ short and wide, the front edge straight except on the inner corner. Sternum as wide as long, widest opposite the second legs. The spinnerets are long, the terminal joints of the outer pair nearly as long as the basal joint. The tracheal opening is nearer the epigynum than the spinnerets. Plate VII, fig. 8.

The cephalothorax, sternum, and mouth parts are reddish brown. The abdomen is light gray with many irregular pale spots and a double row of pale oblique markings in the middle. In the middle of the front half of the abdomen are two orange colored spots. The under side of the abdomen is pale with a few gray spots. The legs are pale with gray rings, two rings on the femur, tibia, and metatarsus. The skin over the epigynum is very transparent and shows two convoluted tubes almost always unsymmetrical, figs. 8*c*, *d*, *e*, *f*. The male palpus has on the outside of the tibia, near the end, a pointed process as long as the diameter of the tibia. At the base of the patella on the outer side is a small pointed black process curved a little forward, fig. 8*b*. The tarsus is nearly as wide as long but slightly pointed at the tip. The palpal organ is flat with a long thin tube extending along the inner side around the end, fig. 8*a*.

Common under dead leaves. Massachusetts, Connecticut, and Mt. Washington, N. H.

Hahnia radula, new sp.

This spider resembles *H. bimaculata* but is nearly twice as large. On the under side of the first and second legs and palpi of the male the hairs are raised on short transverse ridges so that the leg appears serrated when seen from the side. Plate VII, figs. 10, 10*a*. The gray markings of the abdomen and rings around the legs are less distinct than in *bimaculata*. The little spine at the base of the patella of the male palpi is shorter than in *bimaculata* and sharply turned forward. The appendage of the tibia is the same as in *bimaculata*, and the tarsi and palpal organs are very similar.

One male, Jaffrey, N. H., Aug. 1.

Hahnia cinerea, new sp.

PLATE VII, FIGURES 9, 9*a*, 9*b*

Length, 1·5 to 2^{mm}.

Cephalothorax light, with dark radiating markings. Abdomen dark gray with scattered small white spots and a double median row of oblique light markings somewhat like *Cœlotes*. Plate VII, fig. 9. The legs are light yellowish brown with patellæ, coxæ, and the ends of the longer joints paler than the rest. The basal joints of the spinnerets are light yellowish brown like the legs. Terminal joint of outer spinnerets shorter than basal. The tracheal openings are nearer the spinnerets than the epigynum. The skin over the epigynum is rather opaque and but little of it can be seen. The palpi of the male have the patella and tibia both short and each has a long, slender process on the outer side which is flexible and variously curved at the end, fig. 9*b*. The tarsus is short and oval. The palpal organ has at the base a short feather-like appendage. The tube is slender and curved around the distal end of the tarsus. It has near the end a short soft appendage of the bulb, fig. 9*a*.

Salem, Beverly, Swampscott, Cambridge, Roxbury, Mt. Tom, Mass., and New Haven, Conn.

Agalena Walck

Large hairy spiders with long legs and very long upper spinnerets. The head is high and the middle eyes of both rows are much higher than the others. The web is flat and more regular and closely woven than in *Tegenaria*.

Agalena nævia Walck. and Bosc, 1841; Hentz, 1848.

Agalena potteri Blackwall, Ann. and Mag. Nat. Hist., vol xvii, 1846

Agalenopsis albipilis Giebel, Zeitsch Gesammt. Nat., 1869

Agalena americana Keys, Zool. botan Gesellsch, Wien, 1877, male with short-tubed palpal organs, from Illinois.

PLATE VIII, FIGURES 1, 1*a*, 1*c*, 1*d*, 1*f*, 1*g*, 1*h*, 1*i*, 1*j*, 1*k*, 1*l*, 1*m*, 1*n*

This is the common grass spider all over the United States. It varies greatly in size. A large male measures 14^{mm} long, 4th leg 35^{mm}. A large female, 18^{mm} long, 4th leg 30^{mm}, while a small adult male is only 7^{mm} long, and the 4th legs 15^{mm}. Plate VIII, fig. 1.

The cephalothorax is long and the cephalic part separated distinctly from the thoracic by grooves radiating from the dorsal depression. The head is high and wide in front and contracted a little just in front of the first pair of legs. The two rows of eyes

are strongly curved, the lateral much lower than the middle pairs, so that the middle front eyes and the lateral hinder eyes form together a nearly horizontal line. The thorax is marked by radiating grooves between the legs. The abdomen is about twice as long as wide, widest in the front half, a little truncated in front where it overlaps the thorax, and tapering behind. The upper spinnerets are two or three times as long as the under. The legs are long and tapering, the fourth pair longest. The maxillæ are much widened at the tips and nearly straight on the front edges.

The cephalothorax has two wide longitudinal dark stripes. The abdomen has a light longitudinal stripe in the middle, straight in front, and herringbone-shaped in the hinder half, generally a little darkened in the middle and lightest at the edges. The sides of the abdomen are dark, or covered with dark spots close together toward the middle stripe and more scattered toward the sides. On the ventral side the abdomen has a middle dark stripe, sometimes lighter in the middle.

Though the markings vary but little the colors vary from light yellow, with pale gray markings, to dark reddish brown, with black and gray spots, the colors being usually modified by long gray hairs both in dark and light individuals. The joints of the legs are all dark toward the end. Large individuals are, as a rule, darker colored than small ones.

The palpi are long in both sexes. In the males the femur is long, the patella not much longer than wide, and without appendages; the tibia about as long as patella, widened at the distal end, the outer side extending forward along the edge of the tarsus and having a short blunt tooth, figs. 1*c*, 1*g*, 1*d*. The tarsus is large, the basal half oval and the tip narrowed into a long point. The palpal organ, especially the tube, which is largely developed in this species, instead of having a constant form, as in most spiders, varies extremely. The most common form is that shown in figs. 1*a*, 1*g*, with a stout flat tube coiled in one and a half turns under the tarsus, and with the tip turned outward away from the tarsus. On the outer side of the palpal organ near the end of the tube is a short thin tooth with the outer edge turned downward and the corner usually forming a blunt tooth directed toward the end of the palpus. This variety is found in spiders of all sizes and shades of color from all parts of the country. Among large spiders from various localities occurs the form of palpal organ shown in fig. 1*b*. In this the tube is much longer and more slender, and terminates in a sharp

point turned inward toward the tarsus. A third variety, shown in fig. 1*d*, occurs less often but on spiders of all sizes and from different parts of the country. The spiral here hardly makes more than one turn and is so small as to be covered entirely by the tarsus. At the tip the tube is twisted so as to turn the opening downward. This is the form named *Agalena americana* by Keyserling, in 1877, from Illinois; there is one in the Cambridge museum, from Penikese Island, Mass., named by Keyserling "var. *americana*," and I have seen specimens from Indiana, from Providence, R. I., New Bedford, Mass., and Brooklyn, N. Y., in N. Pike's collection. These three varieties seem to be distinct and I have seen no intermediate forms. Fig. 1*e* is a palpal organ from Providence, R. I., having an unusually large tube; fig. 1*f* is the palpus of a small spider from Jaffrey, N. H., in which the tube is slender and the spiral unusually small.

The shape of the external opening of the epigynum is even more variable than that of the palpal organ. The most common variety is shown in fig. 1*h*, taken from a female found in copulation with the male from which the palpus fig. 1*a* was drawn. Figs. 1*i*, 1*j*, 1*k*, show a slight variation from this form by short teeth on the front edge of the opening. Figs. 1*l*, 1*m*, 1*n*, have these teeth united and extending backward across the opening nearly dividing it into two. The three last are all from large dark colored spiders like those having palpi as in fig. 1*b*.

Comparison of a large number of specimens from the neighborhood of Boston, Mass., showed that 69 males had palpi like fig. 1*a*, and 5 like fig. 1*b*; 98 females had the oval epigynum, fig. 1*h*, and 37 the partly divided epigynum, figs. 1*l*, 1*m*, 1*n*.

The web of this species consists of a flat sheet, shaped according to the supports to which it is fastened, from one side of which extends a tube at the mouth of which the spider usually stands. The tube is open at the lower end, from which the spider escapes if the web is entered by too large an enemy.

The webs are made in all kinds of places. In early summer great numbers are made on short grass, but large webs are seldom made in such situations and it is probable that spiders that do not find more favorable places as they grow larger, never live to become adult. The largest webs and the best developed spiders are found among stones and shrubs where there are convenient hiding places and supports for the web, which in a good situation is enlarged as the spider grows until it becomes a foot or more wide and proportionally thick and strong. The long spinnerets are used in making

this flat web, the spider walking along slowly, swinging the spinnerets from side to side, making a band of very fine threads at each stroke. The web does not appear to be at all adhesive, it merely offers insects a convenient place to rest upon and the spider depends on his quickness of movement for their capture. Large webs usually have many supporting threads running up into fences and bushes and these perhaps help to trip the wings of flying insects and cause them to fall on the web, as similar threads do in the webs of Linyphia.

The pairing of this spider takes place on the web of the female. The female lies still with feet drawn up as if dead. The male lays her on one side under his thorax with her ventral side forward and inserts one of his palpi into the epigynum at frequent intervals for a long time, the soft parts of the palpal organ suddenly swelling and again contracting. When tired with one palpus he turns the female around and over so that she lies on the other side with her head in the opposite direction and uses the other palpus. The eggs are laid in a flat white cocoon, usually covered with a thick flat cone of silk with which considerable dirt is often mixed. The eggs are laid under stones or bark and on fences and buildings of all kinds, where they are partly sheltered, from August to October, and the females often remain and die on or near the cocoon. Adults are occasionally found under leaves in winter, but it is doubtful if any live until the next season. The eggs hatch early in the spring and the young spiders come out in May.

It appears to be the most common spider all over the United States.

Dysderidæ.

Spiders with only six eyes and with the openings of the tracheæ in the front of the abdomen, just behind those of the air sacs, so that they appear to have four air sacs like the *Mygalidæ*. The family is a small one and the genera differ greatly in the structure of the feet and mouth parts.

Dysdera interrita Hentz.

PLATE VIII, FIGURES 2, *2a*, *2b*, *2c*, *2d*

Female 12^{mm} long. Cephalothorax 5^{mm} long and 3^{mm} wide. The front of the head is wide and curved forward in the middle. The eyes are small and close together. Pl. VIII, fig. 2. The mandibles are half as long as the cephalothorax and inclined forward and much narrowed toward the end. The maxillæ are small, pointed at the

tips and widest half way to the base of the palpus. Fig. 2*a*. The labium is long and widened at the base. The sternum is widest in the middle, narrowed behind, and truncated at the front end. The coxæ are very long, fig. 2*a*. The first legs are longest and the fourth next. The feet have only two claws and under them a thick brush of flattened hairs. Fig. 2*b*. The patellæ are only about a fourth shorter than the tibiæ. The abdomen is long, oval and a little pointed behind. The cephalothorax and mandibles are reddish-brown. The legs are lighter colored and more yellow and become a little darker from behind forward. The abdomen is dirty white or yellow without markings.

The male differs little from the female. The palpal organ is as long as patella and tibia of the palpus. The terminal half is a little curved inward, and on the outer side is a short blunt tooth a little curved upward. Figs. 2*c*, 2*d*.

Swampscott, Brookline, and Roxbury, Massachusetts. This is the only *Dysdera* I have seen from New England, and as Hentz's *D. interrita* came from Massachusetts, this is probably the species. It agrees very closely with *D. crocata* Koch = *D. rubicunda* Blk. The palpal organ of *D. interrita* is straighter, as seen from in front, than that of *crocata*.

Ariadne Savigny and Audouin.

Ariadne bicolor.

Pylarus bicolor Hentz.

PLATE VIII, FIGURE 3, 3*a*, 3*b*, 3*c*, 3*d*

Female 9^{mm} to 10^{mm} long. Plate VIII, fig. 3. Cephalothorax long and narrow, widest opposite the third pair of legs. In the male the cephalothorax is proportionally much wider. The dorsal groove is very small, and the head is not separated very distinctly from the thorax. The abdomen is oval, widest across the middle. The first, second, and third pairs of legs are turned forward. The first pair is longest, the second next. The legs are all stout and the first and fourth pairs have the patella and tibia much thickened. The color of the cephalothorax and legs is darker from behind forward, the fourth legs being light yellow and the first legs and front of the head dark brown. The abdomen is pale at the sides and dark purplish-brown above and below, darkest along the middle of the back.

The feet have three claws, fig. 3*d*. The tibia and metatarsus of the first and second legs have two rows of strong spines on the under side, four pairs on the tibia and eight or ten pairs on the metatarsus. The sternum is long and widest in the hinder half. The maxillæ are

long and narrow, widened a little half way btween the tip and the insertion of the palpus. The palpi are short and stout, fig. 3. The middle eyes are close together. The upper lateral eyes are about twice their diameter from the middle pair, and the front eyes are close to them, about half their diameter nearer the middle line.

The male is a little smaller than the female and has the thorax wider and the legs longer and more slender, fig. 3*a*. The metatarsus of the first feet is crooked at the base with a spine on each side, the outer one nearest the base, fig. 3*a*. The male palpi are but little longer or stouter than those of the female. The tibia is a little thickened. The palpal organ is attached to the under side of the tarsus; it has a round bulb about as thick as the tibia is long, which narrows on the outer side into a short finely pointed tube that curves sharply inward, fig. 3*a*.

It lives under stones and leaves, or in long yellowish tubes only wide enough to hold the spider under stones or in cracks of trees. In July and August the cocoon with twenty or thirty eggs is made in the tube with the female, and the young come out of the cocoon and live in the tube for a short time with the female.

Massachusetts, Connecticut, and in N. Pike's Long Island collection.

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[Presented to the Connecticut Academy of Arts and Sciences, May 20th, 1891.]

XII.—The Development of a Paleozoic Poriferous Coral. By Charles E. Beecher. (With Plates IX–XIII.)

The origin and affinities of many groups of paleozoic corals are still obscure. The main elements of the recognized system of classification seem to be stable, yet so little is known of the growth and structure of a number of important groups, that they occupy a different place in almost every arrangement of the genera. Each fact of development affords data which eliminate, to a degree, the want of knowledge concerning their origin and relations. Unless the growth of the organism is obscured by pronounced accelerated or degradational features, its interpretation is simple, and throws much light on its ancestral history. Paleozoic types in general are least modified in their development by acceleration. They usually show some marked expression of their prototype, and also the succession of changes through which they have passed during their evolution

The species here discussed was originally described as *Michelinia lenticularis*, Hall,* from the Lower Helderberg group of New York. If *Michelinia* is entitled to recognition, it will exclude this form, as it is without tabulæ. *Pleurodictyum*, as now defined, is more in harmony with these features, and, therefore, the species *M. lenticularis* is here referred to this genus. The large calices and their constant origin at the basal epitheca are not, however, essential characters of *Pleurodictyum*. The structure and growth of this species indicate that it represents one of the simpler types of poriferous corals. For this reason, its development is without the numerous modifications necessary in more complex forms, and its laws of growth are not complicated.

Development of Pleurodictyum lenticulare.—The nepionic stage is well marked. It comprises the growth of the corallum to the completion of a simple initial cell. This primitive cell or nepionic stage (Plate IX, figure 1, 7, 8) has the form of an oblique inverted cone flattened on one side. The flattened area represents the lower or attached side, and the oblique base of the cone is occupied by the

* Twenty-sixth Rept N Y. State Museum of Nat Hist, p 113, 1874

aperture of the corallite. The apical portion is smooth for about one-fourth the length of the cell. Then the concentric lines of growth become apparent, and over the distal half radiating ribs are also developed. The interior of the apex is granulose. At about the middle of the cell, the granules are arranged in rows, forming the beginnings of the septal lines.

The simple growth of the initial cell continues until the entire procumbent portion is completed. A thickening of the margin then takes place, and an upward growth of the corallite is initiated. At the commencement of this upward growth, the first bud starts out from the lateral edge of the initial calyx, either to the right or left of the axis. This condition represents the first nealogic stage. The bud resembles the parent cell in all particulars, and reaches considerable size before the second appears, as shown in Plate IX, figures 9, 10. The visceral cavities are confluent, as the initial apex of the bud opens into the calyx of the first cell

The succeeding nealogic stages, to the completion of the first circle of peripheral calices, have been observed mainly from the epithecas of mature or nearly full grown corallums, represented on Plate X, figures 1, 2. In these examples, the lines of growth are so perfectly shown, that all the stages are distinctly marked, and may be satisfactorily studied.

What is here considered as the second nealogic stage is represented on Plate IX, figure 3, showing the initial corallite, with the first and second buds on opposite sides. This process of alternate gemmation from the parent cell continues until the circlet of calices is completed, as shown in figures 4, 5, and 6. In this species, the normal number of peripheral calices is seven, making eight corallites in the completed nealogic corallum. The last cells to be formed are (1) the sixth and seventh budding from the anterior side of the first calyx, and (2) the eighth or posterior cell. Plate IX, figure 12, represents the completed nealogic corallum, with the initial cell and six well developed peripheral calices. The eighth has just begun to fill up the space between the second and third. It will be noticed that there is a direct correspondence in the size of the calices to their relative age. The first calyx is much the largest. Then, decreasing serially, come the second, third, fourth, fifth, sixth, and seventh, while the eighth is undeveloped. An inspection of the upper surface of a mature corallum will thus usually determine the order of successive calical additions. After the appearance of the posterior, or eighth calyx, the corallum commonly grows to double

the diameter of the completed nealogic stage, resulting in the normal ephebolic or mature condition, as represented on Plate XI, figures 1, 2. Nearly all the full grown specimens found agree in this respect.

A corallum rarely presents any departure from the normal number of calices. Plate XII, figure 1, is an example of a variation in the number of peripheral corallities, for in this specimen, there are eight in the circle, instead of the usual seven. A variation in the opposite direction is shown in another specimen having five well developed corallites about the parent cell. Old age characters are expressed in two ways: First, the cell walls become thickened around the margin of the epitheca without destroying the symmetry of the corallum, as shown in Plate XII, figure 2; Second, by the indefinite and unequal development of the peripheral cells, together with the addition of calices budding from the cells forming the primary circle. One specimen, appearing at first sight as an example of cell division or fission, is shown in Plate XIII, figure 2. It may be explained as resulting from the abnormal growth of the second and adjacent calices, four and eight. This lateral impulse further resulted in sending off the small, peripheral, tertiary corallites numbered in the figures 9, 10, 11, 12, and 13.

It should be understood that this arbitrary expression of normal and abnormal growths applies only to the species *P. lenticulare.* The same numerical arrangement will not hold good for genera like *Favosites*, *Michelinia*, *Striatopora*, etc. Otherwise, it is believed, the general laws of growth here brought out will hold good for these and other related genera.

Some doubt may exist as to the propriety of referring the specimens illustrated on Plate IX, figures 9–11, to *P. lenticulare.* Unfortunately, material of this kind is rare and difficult to obtain. With the exception of the position and direction of the first bud (figure 10), all the characters agree, so far as can be observed, with ordinary specimens of *P. lenticulare.* The second cell of the corallum represented in Plate X, figure 1, curves rapidly backwards, although at first the axis has an anterior direction. Taking this view of the specimen, Plate IX, figure 11, it is not difficult to see how the succeeding enlargement and curvature of the bud could extend backwards, thus properly limiting the size of the eighth or last of the primary circlet of calices.

The method of determining the relative age and succession of the corallites can be seen in Plate X, figures 1, 2, and Plate XI, figure 2.

The initial cell occupies the central position, and forms the boss or apex of the basal epitheca. The first bud is nearly on a plane with the base of the initial cell and is the one nearest the apex. The second and successive buds are respectively more distant, and at a higher level. Specimens having broad surfaces of attachment to foreign objects have these distinctive features of the epitheca obliterated, and the only guide to the order of the corallites then lies in their comparative size and position on the upper surface of the corallum.

General conclusions.—The first feature to be noted in the development of a poriferous coral, as here described, is the simple cyathiform character of the initial corallite. This nepionic stage is without mural pores, and has an epitheca over the entire exterior of the cup. The septal lines become developed toward the end of this stage. These features are in harmony with the young of many paleozoic corals, such as *Cladochonus*, *Aulopora*, or *Syringopora*, and clearly indicate a primitive, simple, and imperforate ancestry for the Perforata. A similar origin and development obtains in *Favosites*, as may be seen from the figure of a young colony of *F. Forbesi*, var. *occidentalis*, given by Professor Hall.*

The first nealogic stage, represented by the primitive corallite with one bud, is the first transition towards both a compound and a perforate coral, Plate IX, figure 9. This stage has two calices, making it a compound coral, and has an opening through the cell walls or connecting channel between the corallites, forming the first mural pore. The manner of growth and the structure of the corallum at this stage are suggestive of *Aulopora*, and should be given considerable significance. The visceral cavities in *Aulopora* are confluent, and rudimentary septa or lines of spinules are often present.' *Romingeria* has a growth resembling *Aulopora* and *Syringopora*. It is without pores on the portion where the corallities and buds are free, but when these are in juxtaposition at their bases, mural pores are developed. The upward growth of the initial cell of *P. lenticulare* proceeds but a short distance before the circlet of peripheral corallites is completed. Thus at this stage there are at least seven mural pores opening into the primary calyx. If this tendency to the formation of numerous buds persists throughout the upward growth

* Indiana Geol. and Nat. Hist., 11th Rept. of the State Geologist, pl. i, figure 12, 1881.

of the corallites, the non-development of the buds consequent upon the adjacent living corallites would naturally result in the production of mural pores. The basal epitheca limits the fleshy portion of the organisms, and represents an area unfavorable to the acquisition of food or for the natural development of calices. Therefore, it would prevent both the maintenance of mural pores and the growth of basal buds.*

A *Favosites* in which one or more cells became inactive or dead shows in its subsequent growth the closing over of this area by the budding of the surrounding cells. Each cell is connected with the parent by an apical pore, Plate XIII, figures 3, 4. Without this opportunity to bud afforded by the death of one or more corallites, or by their divergence, the adjacent cells would have developed only mural pores. In the figure of *P. problematicum* given on Plate XIII, figure 2, three of the initial pores are indicated by dotted lines from *p*. No distinction can be made between these and the ordinary pores, except that the latter are usually not as large. This difference in size would be expected, as the primary pore represents the bud which succeeded in producing a corallite; whereas the other attempts at budding resulted no further than the production of mural pores. The conclusion to be drawn is, that the mural pores in such genera as *Favosites*, *Striatopora*, *Pleurodictyum*, *Michelinia*, etc., are ineffectual attempts at budding, resulting only in the perforation of the cell walls. This explanation agrees with the pronounced and persistent tendency to gemmation characteristic of the genera mentioned. They also represent compound forms having individualized epithecas, and this feature naturally arises from the same system of budding obtaining in the simple corals.

Professor Verrill has shown that the presence or absence of tabulæ is of little or no importance in a natural classification.† Therefore, the non-tabulate feature of *P. lenticulare* is without special consequence in a discussion of the relations of this species with *Favosites*, or other tabulate poriferous genera.

* The presence of basal mural pores or openings through the epitheca has been asserted by Meek and Worthen (Pal. Illinois, vol. iii, p 409, 1868). The specimens from which this observation was made, are from a friable sandstone, which does not usually preserve minute details with much distinctness The depressions between the spinules on the septal lines could easily be mistaken in a cast for the fillings of mural pores, and it is believed by the writer, that this interpretation should be given. *P lenticulare* occurs as calcareous or silicified, and in the condition of casts No basal mural pores are present. Also, none can be observed in the casts of *P problematicum*, from Pelm, Germany.

† Am. Jour. Sci., vol. iii, p 187, March, 1872.

If the preceding interpretations of structure and affinites are correct, a simple, conical imperforate, non-tabulate prototype, or protocorallum, may be assumed for the Madreporaria Perforata. The next derived form, represented by the early nealogic stages of *P. lenticulare*, has the structure and growth of *Aulopora*, and consists of the parent cell with one or more buds. At this stage, which may be called the *Aulopora-stage*, the initial corallite has the same number of mural pores as developed buds, for each bud leads into the parent cell by a basal opening or pore. *Aulopora* may thus be considered as representing a primitive type of a poriferous coral, in which the number of pores in each corallite corresponds to the number of buds given off plus one connecting it with the parent cell. Some species of this genus are free throughout most of their growth (*A. subtennis*, Hall), agreeing closely with the erect growth of *Romingeria* and *Syringopora*. This fact removes one of the important arguments against the relations of *Aulopora* with these genera. The corallites of *Aulopora* usually send off buds before turning out of the common axis of the branch or colony, after which no gemmation commonly takes places. By the explanation here advanced, this lack of a tendency to gemmation in the distal portions of the corallites in this genus accounts for the absence of mural pores when such portions are in contiguity. The periods of gemmation in *Romingeria* are periodic. Several buds, often forming a verticil are given off from the parent corallite. Considerable elongation of the tubes takes place before other series of buds are produced. The budding is prolific at these points, and here also occur the mural pores. The latter are therefore developed when the period of gemmation is in force. If pores are formed elsewhere when the corallites happen to come into juxtaposition, it may possibly be explained as the result of a stimulus produced by the contiguity of the animals. Further observations are necessary to show that pores exist at other places than the bases of the verticils or points where numerous buds are given off and where from crowding the corallites are in juxtaposition.

It therefore seems, that, primarily, the development of mural pores is identical or homologous with the process of gemmation. Whether this cause is operative in such forms as *Columnopora* or *Alevopora* yet remains for investigation. The porous condition of the walls in these genera may be an inherited character without an active exciting cause, or it may be teleologically different.

Yale Museum, New Haven, Conn., May 20th, 1891.

EXPLANATION OF PLATES.

PLATE IX.

Pleurodictyum lenticulare.

Fig. 1. Lower side of initial cell, or nepionic stage. × 3½.

Fig 2. Lower side of initial cell with one bud; first nealogic stage. × 3½.

Fig. 3. Initial cell with two buds; second nealogic stage. × 3½.

Fig. 4. Initial cell with three buds; third nealogic state. × 3½.

Fig. 5. Initial cell with four buds; fourth nealogic stage. × 3½.

Fig. 6. Completed nealogic stage; showing initial corallite (1) and seven peripheral corallites (2-8). × 3½.

Fig. 7. Interior of nepionic corallite. × 3½.

Fig. 8 Exterior of same specimen × 3½.

Fig. 9. Upper side of specimen representing first nealogic or *Aulopora-stage*, consisting of nepionic cell and one bud Apex of bud opens into visceral cavity of parent cell. × 3½.

Fig. 10. Profile of same; showing oblique apertures of corallites, and thickened margin of parent cell × 3½.

Fig 11. Lower side of preceding. × 3½.

Fig. 12. Upper side of completed nealogic stage; showing inception of eighth cell. × 3½.

Figs. 1–6 are taken from epithecal lines of growth shown in Plate X, figure 2. Remaining figures are from actual specimens. Numbers refer to order of calical succession.

Lower Helderberg Group. *Albany County, New York.*

PLATE X.

Pleurodictyum lenticulare.

Fig. 1. Lower or epithecal side of specimen; showing successive alternate gemmation from parent corallite. × 3½.

Fig. 2. Similar specimen with lines of growth more strongly marked. The order of budding is opposite to that of preceding specimen. × 3½.

Lower Helderberg Group. *Albany County, New York.*

PLATE XI.

Pleurodictyum lenticulare.

Fig. 1. Outline of calices of specimen Plate X, figure 2; showing central primary cell and seven peripheral calices numbered in the order of their development. × 3½.

Fig. 2. The same; side view.

Lower Helderberg Group. *Albany County, New York.*

PLATE XII

Pleurodictyum lenticulare

Fig 1 Outline of upper side of specimen with eight peripheral calices × 3½

Fig 2. Upper side of symmetrical specimen, showing general features of calices, mural pores in central corallite, and thickened epithecal border × 3½

Lower Helderberg Group *Albany County, New York.*

PLATE XIII

Pleurodictyum lenticulare

Fig 1 Calical diagram of geratologic specimen, showing enlargement of second, fourth, and eighth corallites, and the addition of tertiary cells forming a second series of peripheral calices × 3½

Lower Helderberg Group *Albany County, New York*

Pleurodictyum problematicum

Fig 2 Lower side of cast of corallum with epitheca removed showing proximal extremities of several corallites Upper edge of figure represents portion of periphery of corallum Thus, lower angle of each corallite represents the point of budding from parent cell and is connected with it by a pore shown for three of the corallites by dotted lines from *p* It will be noticed that all the pores in the angles are larger than the others Otherwise, these and the initial pores cannot be distinguished from the ordinary mural pores between the flat sides of the corallites × 7

Devonian *Pelm, Germany*

Favosites epidermatus ?

Fig 3 Side view of mature corallite with attached intermural bud Specimen broken from interior of a large colony × 3½

Fig 4 The same front view, with bud removed, showing pore or mural opening (*p*) at lower point of attachment of bud, corresponding to those indicated in figure 2 × 3½

Corniferous limestone *Cherry Valley, New York*

XIII.—Symmetrical Cell Development in the Favositidæ. By Charles E. Beecher. (With Plates XIV, XV.)

The majority of compound corals included in the *Favositidæ* are composed of polygonal, prismatic cells or corallites in juxtaposition. When, however, these cells become free, their form is cylindrical. The polygonal form of closely arranged cells is therefore explained as the natural result of crowding.

The species *Pleurodictyum lenticulare*, Hall, sp., is an example of simple cell growth and multiplication. In the development of this species, as shown by the writer in the previous paper, the initial corallite is first conical. The growth of a peripheral series of buds results in changing the sub-circular section of the parent corallite into a polygon. The buds are angular on the sides in juxtaposition to the parent cell and adjacent buds, but on the free portion of their periphery they are cylindrical. The subsequent growth of peripheral buds brings the first series wholly within the corallum, and they are then polygonal in section like the parent corallite.

In compact corals with long cell tubes, as *Michelinia* and *Favosites*, there is a maximum limit to the size of the corallites. Thus, the form of the cells which have reached this limit of diametral extension is that of equal hexagonal prisms. This is of course due to the well known fact of six equal tangent circles about a central circle of the same size. Then from crowding, or from the elimination of the interstitial spaces, they assume a regular hexagonal form. The specimen of *Cleistopora geometrica*, illustrated by Edwards and Haime,* represents the maximum size of the cells and their equal development in this species. Although the tubes are not long, the calices are nearly of the same size, and regularly hexagonal.

After the completion of a circle of calices about the parent cell of the corallum, enlargement takes place, (1) by buds from the periphery, and (2) by intermural gemmation. The first is not attended by any phenomena differing from the production of the primary circlet of calices about the initial cell. The second takes place under other conditions, and is the chief method of increase in the growth of large corallums having numerous corallites.

* Monographie des Polypiers Fossiles des Terraines *Palæozoïques*, p. 252, pl. 17, fig 3. 1851.

The radial arrangement of the tubes in a large hemispherical or cylindrical mass tends to make the axes of the corallites diverge. This divergence can be taken up only by an increase in the diameters of the tubes, or by the addition of new calices between the others. The latter mode is called intermural gemmation. In *Favosites* and allied genera, the maximum size of the corallites is soon reached, and the expansion of the coral is mainly derived from intermural growth. The study of this method of increase, properly begins after one or more rows of calices have been developed about the parent cell, and the calices have reached their full dimensions.

The following description of a symmetrical system of intermural cell multiplication was observed in a hemispherical specimen of *Michelinia convexa*, D'Orbigny, from the Corniferous limestone of the Falls of the Ohio. It shows very clearly the stages of development of the interstitial buds, and their modifications. Other corals were examined to the same end, and were found to agree in all essential particulars, whenever their growth was not irregular from their condition of fixation, or from the excessive development or death of a number of the corallites. An exact number of peripheral buds is not necessary to illustrate the general laws of intermural growth. The buds produced from any given cell cannot always agree with symmetrical method here described, on account of the crowding of similar series from adjacent or neighboring corallites. After eliminating these variations, it was found that the process of intermural gemmation in general is quite uniform, and closely conforms to that in *Michelinia convexa*.

Plate XIV, figure 1, represents diagrammatically the top of a corallum composed of a central parent cell and six equal peripheral buds, making seven nearly equal calices in the corallum. The upward growth of these corallites and the divergence due to the direction of their axes tend to separate them from the parent cell. In consequence of this separation of the corallites, they would naturally assume a cylindrical form, and there would thus appear triangular interspaces between the tangent points of any three adjacent calices. These angles, therefore, afford the only opportunities for the introduction of a set of intermural buds, and their initial triangular form is determined by the conditions of growth. The smallest number of buds which can be symmetrically placed and compensate for the divergence of the corallites is three, one from each alternate angle of the hexagon, Plate XIV, figure 2.

If these interstitial cells were to grow without the introduction of others, until the original peripheral series was completely separated from the parent or central cell, there would result a corallum containing only triangular corallites. There is, however, a manifest tendency of the organism to the production and maintenance of a cylindrical form, or of a prism with nearly equal radial axes, as in a hexagonal or polygonal prism. To accomplish this, and further to take up the divergence of the corallites, three new interstitial buds are introduced at the remaining three unmodified angles, as shown in figure 3. At this stage, there are six symmetrically disposed triangular buds, or intermural cells, about the central corallite, truncating its original angles, and making it a twelve sided prism. This stage is the third toward the formation of a series of mature interstitial calices.

During the third stage, the intermural buds increase in size until they completely surround the parent cell. Then further growth truncates their adjacent angles, thus adding two more sides to each bud, making them pentagonal in section. This marks the fourth stage of intermural growth. At the same time, the central corallite loses six of its sides, and returns to its early hexagonal form. The axes have revolved 30°, and the original sides have now become the angles of the corallite, Plate XIV, figure 4.

At this period of growth, it is necessary to consider a series of buds on the periphery of the corallum, marked 1″, 2″, etc., in Plate XIV, figures 3 and 4. They are first triangular in form like the others, and of two sizes, owing to their different ages. The growth of this series continues until they touch and truncate the angles of the first series (1′, 2′, etc.), producing the fifth condition or stage. The first series of buds has now three hexagonal and three pentagonal corallites, Plate XIV, figure 5.

In the last or sixth stage, figure 6, the further growth of all the intermural cells results in a corallum of nineteen nearly equal hexagonal corallites. The original parent cell (1) is at the center, the first six intermural cells (1′, 2′, etc.) completely surround it, and the six new peripheral corallites (1″, 2″, etc.) are interposed between the members of the original circlet (1, 2, etc.). The effect of this intermural growth, then, is to dissociate all the first series of corallites from the parent cell and from each other.

The changes taking place in the number and form of the cells may be tabulated as follows :

Stages	Form of primary cell	Whole No of cells	Number of intermural buds.	Number of sides of buds
Nepionic	cone	1	0	0
First completed nealogic or first condition requisite to intermural gemmation	6 sided prism.	7	0	0
2d stage.	9 sided prism.	11	3	3
3d stage	12 sided prism.	16	9	3
4th stage	6 sided prism	19	12 { 6 6	{ 3 5
5th stage	6 sided prism	19	12 { 3 3 3 3	3 4 5 6
6th stage.	6 sided prism.	19	12	6

Buds are developed in *Favosites* and *Michelinia* whenever* there is a space or opportunity for their growth, unless the corallum is affected by some abnormal condition. If this tendency to form a solid mass of corallites were not so strong, and if the process of budding took place only at comparatively remote intervals, the corallum would have the form of *Romingeria.* It is evident in *Michelinia convexa,* that if the divergence of the corallites was considerable and not wholly filled by intermural growths, there would result a verticil of corallites about the parent cell which would soon become free. The peripheral corallites, also, would become separated. Then after further growth, the parent cell would give off another verticil of buds, the other corallites, likewise, develop similar verticils, and the whole form and mode of growth be like that of *Romingeria.* From this point of view, *Romingeria* may represent an early form of symmetrical cell development in the poriferous corals. The acceleration of the periods of gemmation, and consequent approximation of the corallites carrying their verticils of buds, would produce all the conditions of cell growth and intermural gemmation exhibited by *Favosites* or *Michelinia.*

Summary :—The growth of intermural buds compensates for the natural divergence of the corallites. New cells are introduced whenever the old corallites have reached their maximum size, and when their divergence approaches a separation of the cell tubes.

The form of the buds is first that of a triangular pyramid or prism, and is due to the mechanical conditions of growth. During subse-

quent increase, they touch and truncate each other, changing from triangular to five- and six-sided prisms. Complete symmetrical normal development produces a corallum with equal hexagonal calices. The process of intermural gemmation changes the sides of the parent cells to angles, and the older corallites, originally in juxtaposition, become separated from each other by new series of interstitial calices.

Yale Museum, New Haven, Conn., May 20th, 1891

EXPLANATION OF PLATES.

Plate XIV.

Michelinia convexa.

Fig 1. Diagrammatic representation of upper surface of corallum; consisting of parent cell, A, and six peripheral corallites, 1, 2, 3, etc.

Fig. 2. The same, showing the introduction of three triangular intermural buds, 1′, 2′, 3′, etc.

Fig. 3. Third condition; with six triangular buds about the parent corallite, and three on the periphery of the corallum.

Fig. 4. Top of corallum; showing further growth of preceding corallites, with the addition of three peripheral calices, 4″, 5″, 6″.

Fig. 5. The same during a succeeding stage: showing increase in size of corallites, and modifications produced

Fig. 6. Completed growth of first system of intermural gemmation; showing dissociation of original series of corallites (A, 1, 2, 3, etc.), and representing condition preparatory for new series of interstitial corallites.

All figures natural size.

Plate XV.

Michelinia convexa.

Fig. 7. Development of a group of corallites from initial conical cell to corallum with nineteen calices. The figure represents parallel horizontal sections through the corallum; showing the number and form of the calices, their order of development, and the modifications taking place during growth. The parent cell is marked A; first series of calices, 1, 2, 3, etc; first series of intermural buds, 1′, 2′, 3′, etc.; peripheral series, 1″, 2″, 3″, etc. Notation corresponds with that of preceding plate.

Natural size.

XIV.—New England Spiders of the family Attidæ. By J. H. Emerton.

The Attidæ are distinguished by a peculiar arrangement of the eyes. The front of the head is wide and square and the front row of eyes directed forward and nearly straight or with the lateral pair a little the highest. The front middle pair are larger than the others and often much larger, so that at first sight the spider appears to have but two eyes. Behind the lateral eyes of the front row are two very small eyes and still farther back, often near the middle of the cephalothorax, are two others a little larger, sometimes as large as the front lateral pair. See figures on Plates XVII and XVIII.

The relative length of the legs is very variable. The fourth pair is usually the longest, but often the first, and even in some species the third pair. The legs of the first pair are usually thickened, and often those of the second pair. Most species can jump a considerable distance and this seems to be done from all the legs at once and does not depend on their relative length or size. The feet have two claws, generally long and with many small teeth, and, under the claws, a bunch of long hairs. The colors of the Attidæ are generally bright and of great variety. They are partly caused by colored scales and hairs which in some species cover the whole body and in others are so small that the color of the skin shows between them. The scales are usually long and narrow like flattened or branched hairs, Pl. XVI, figs. 1*j*, 1*k*, others, especially those forming the white spots, are short and flat, fig. 5*d*. Some of the scales of many species have a metallic luster and their color changes with the direction of the light. As spiders become older part of their scales rub off and so change their color. In alcohol great changes in color take place. The wetting of the scales makes them transparent and the colors of the skin show through them. For this reason the front of the head and around the eyes is black or dark colored in most species in alcohol while the same parts in life are covered with white or light colored scales. Pl. XVII, figs. 2, 2*a*. Some species that are yellow or brown when alive turn red in alcohol as *Dendryphantes militaris* and *æstivalis.*

The northern Attidæ, like the Drassidæ, are generally of middle size, none of them being as large as the larger Lycosidæ and Epeiridæ,

or as small as a large part of the Therididæ. Some species live on the ground and under stones and leaves but most of them on plants and in open places. They make no webs except nests in which they hide in winter, or when moulting or laying eggs. The pairing of some species takes place in the nest, and the males of several of them enter the nest of a young female and wait for her to mature. The habits of the Attidæ, especially the fighting and mating habits of many species, have been described by G. W. and E. G. Peckham, in the papers of the Wisconsin Nat. Hist. Society of 1889 and 1890.

The palpi of the males are less variable than in most families. They are usually stout and short with a short tibial hook and short tube to the palpal organ, the end of the tube resting in a groove in the end of the tarsus. The end of the tarsus is obliquely flattened and covered closely with short fine hairs.

A large number of the American Attidæ have been described. Hentz described some forty species under fifty-one names. Many of these are comparatively easy to identify but as with other families probably a quarter of them will always remain uncertain.

The species described by Walckenaer and Koch are even more uncertain than those of Hentz. A considerable number of them are very probably the same as species described here and in the papers of Mr. Peckham, but the descriptions and figures are in most cases too indefinite to be identified.

The spiders described by Keyserling, in 1885, are, most of them, in the Museum of Comparative Zoology, at Cambridge, Mass., and I have examined and identified most of them. More species have lately been described by G. W. Peckham and Mrs. Peckham, who have made a specialty of this family, in the Transactions of the Wisconsin Academy of Sciences for 1888. I have compared specimens of these species with my own. I have also had for comparison a number of European Attidæ named for me by Mr. Simon. The classification of the American *Attidæ* needs a more thorough revision than can be undertaken in a paper dealing with so small a number of species as the present and it will no doubt soon be done by Mr. Peckham. The classification of Simon as modified by Peckham has been followed as far as possible.

The species are included in the following genera:

Phidippus Koch. Large hairy spiders. Mandibles large and strong and longer than the front of the head. Cephalothorax widened across the middle. Anterior row of eyes comparatively small and a little separated from one another, the lateral higher than

the front pair. Middle eyes nearer the lateral than the dorsal. Legs short and stout 4, 1, 2, 3 in females and 1, 4, 2, 3 in males. Males with longer legs and deeper colors than females. Male palpi with a short tibial hook and short tube of the palpal organ. *P. rufus, ruber, brunneus, mystaceus, tripunctatus*, page 224 to 228.

Dendryphantes Koch. Hairy spiders of moderate size. Front row of eyes large and short distances apart, the lateral only a little higher than the front pair. Middle eyes half way between the lateral and dorsal or a little nearer the lateral. Mandibles large and strong, those of the males spreading a little apart and having a sharp edge on the outer side. Legs 4, 1, 2, 3 in females and 1, 4, 2, 3 in males. Colors of the sexes very different. Females brown and gray, indistinctly marked. Males darker brown with bright white markings, color of skin changing to red in alcohol. *D. militaris, montanus, æstivalis*, page 228 to 230.

Icius Simon. I use this genus as it has been used by Keyserling and Peckham to include several species that must soon be separated into two or three genera. *I. mitratus* and *palmarun* resemble *Dendryphantes*, but have the cephalothorax more flattened, the abdomen narrower and longer, and the front legs of the males more elongated. The other species approach *Epiblemum* and *Menemerus*. They have the cephalothorax elongated, the colors dark and the hairs and scales very small and partly iridescent. The legs are marked with longitudinal lines and the front pair much elongated. *I. palmarum, mitratus, elegans, hartii, formicarius*, page 232 to 236.

Marptusa Thorell = *Marpissa* Simon. Cephalothorax and abdomen much flattened and both widest across the middle. Cephalothorax very low in front, the front eyes touching its lower edge. Lateral eyes half their diameter from the front pair. Mandibles small. Legs 4, 1, 2, 3, in females and 1, 4, 2, 3, in males. *M. familiaris*, p. 237.

Epiblemum Hentz = *Calliethera* Koch and Simon. Cephalothorax more than half longer than wide, a little widened in the middle and depressed in the middle between the cephalic and thoracic parts. Abdomen oval, not much longer than the cephalothorax. Legs 4, 1, 2, 3, in females and 1, 4, 2, 3, in males. Mandibles of the males elongated and turned forward. Distinct white markings on cephalothorax and abdomen. *E. scenicum*, page 238.

Menemerus Simon. Cephalothorax half longer than wide, widest a little behind the middle, flattened above, and with a deep groove across the middle. Legs 4, 1, 2, 3, or 1, 4, 2, 3, front legs thickened. Colors in longitudinal stripes. *M. binus, lineatus*, page 239.

Mævia Koch. Cephalothorax high and wide, but little widened in the middle. Mandibles small. Legs long, slender and tapering, differing little in length, 4, 1, 2, 3. Hairs and scales short and colors bright. *M. vittata*, page 236.

Zygoballus Peckham. Cephalothorax high. Eye space nearly as long as wide and widest behind. Dorsal eyes very high and wide apart. Mandibles large in both sexes, those of males with spines on the inner and under sides. Legs 4, 1, 2, 3 and 1, 4, 2, 3. *Z. bettini*, *terrestris*, page 230, 231.

Phlegra Simon. Cephalothorax long with the cephalic part short, about half as long as the thoracic. Lateral eyes higher than the front pair. First and second legs short and thickened. Legs 4, 3, 1, 2 or 4, 1, 3, 2. Markings in longitudinal lines. *P. leopardus*, page 242.

Hasarius Simon. Cephalothorax a third longer than wide, widest in the middle and flat above. Abdomen larger than cephalothorax, widest across the middle, and pointed behind. Dorsal eyes as far apart as lateral. Legs of third and fourth pairs of equal length. First or fourth pair longest. The cephalothorax has usually a band of light color across the middle behind the eyes. *H. hoyi*, page 243.

Habrocestum Simon. Cephalothorax high, longer than in Attus and the dorsal eyes farther back. Colors black and white in females and bright and iridescent in males. Third legs longest. *H. splendens*, *peregrinum*, page 244, 245.

Attus Walck., Simon. Cephalothorax nearly as wide as long, widest in the middle. Eye space two-thirds as long as wide. Dorsal eyes as far apart as the lateral. Third legs shortest. Fourth legs longest in females and usually in males. *A. palustris*, *sylvestris*, page 247.

Saitis Simon. Small spiders with the cephalothorax long and widest behind. Dorsal eyes nearer together than the front lateral. Abdomen short and wider than the cephalothorax. Third legs as long as fourth and longer than first. *S. pulex*, page 246.

Euophrys Koch, Simon. Cephalothorax low and wide in front, long and with the sides almost parallel. Legs 4, 1, 2, 3, first and second pairs thickened. Hairs short and skin in the females marked with gray and brown spots like Tegenaria. Males darker colored. Some species with long hairs and scales and markings like *Attus*. *E. monadnock*, page 241.

Neon Simon. Small spiders with large eyes; the dorsal pair as large as the lateral and nearer the back than the front of the cepha-

lothorax. Hairs short and skin marked with gray spots. *N. nellii.*, page 240.

The three following genera are ant-like in general appearance. They are long and narrow. The pedicel of the abdomen is long and visible from above. Abdomen and cephalothorax each with a depression near the middle; legs slender.

Synageles Simon. Dorsal eyes as far back as the middle of the cephalothorax. Transverse depression very slight. Cephalothorax flattened above, the hinder half narrowing slightly backward. *S. picata*, page 250.

Salticus Latreille, Simon. Cephalic part of cephalothorax higher than the thoracic. Mandibles large. Palpi of females with tibia and tarsus thickened. *S. ephippiatus*, page 249.

Synemosyna Hentz. Very long and narrow. Depressions in cephalothorax and abdomen deep. Cephalothorax and abdomen both narrowed toward the pedicel. Middle eyes very large; the others all small. *S. formica*, page 248.

Phidippus multiformis, new sp.

Phidippus rufus Peckham, but not *Attus rufus* Hentz, nor *A. castaneus* Hentz, nor *Phidippus ruber* (Keyserling) Peckham. Keyserling has named this species *Phidippus auctus* Koch in the Cambridge museum.

The female is 8 to 9^{mm} long, the male 5 to 7^{mm}. The general color of the adult female is yellowish brown with black and white markings. Around the front of the abdomen is a white band, and on the back are two indistinct longitudinal black stripes in which are four pairs of white spots. The general brown color is produced by a mixture of scales and hairs of various colors. The females are most brightly colored just before reaching maturity. The general color is then a bright orange, mixed with darker red and brown scales and black hairs. The cephalothorax is covered with yellow scales inclining to red in the middle of the back. The black stripes on the abdomen are more distinct and the white spots larger. Pl. XVI, fig. 1*b*. The legs are pale in the middle of the joints and dark toward the ends and covered with gray and black hairs. The palpi are yellow. The hairs and scales are of various shapes, the most common being that of slightly flattened hairs, fig. 1*j*. These, with black hairs, form the darker colors. The yellow and orange scales are wider and less sharply pointed, fig. 1*k*, and the white spots have short and wide scales. Under the abdomen the color is light gray with two parallel darker stripes. In younger spiders the black

markings of the abdomen are larger and the white markings of the hinder half larger and wider. The yellow parts are paler and the joints of the legs are less darkened toward the ends. In very young, just after leaving the cocoon, fig. 1*d*, the legs are entirely pale, except the claws, which are black; the cephalothorax is black with a few yellow scales. The abdomen, which is very short, is black with a yellow marking along the middle and around the front half. The two hinder pairs of white spots are twice as wide as long, and the other pair are very small.

In alcohol the orange color disappears almost entirely. The palpi remain light yellow and the colors of the legs become lighter and darker shades of yellowish brown. The cephalothorax is dark brown, darker on the head, and the abdomen becomes brown with the black and white markings still distinct but faded.

The colors of the male are entirely different from those of the female, fig. 1*a*. The cephalothorax and legs to the end of the tibia are black. The metatarsus and tarsus of all the legs are reddish brown with black ends. The palpi are black with a stripe of white scales on the upper side of patella, tibia and half of the tarsus. Abdomen black beneath and in the middle above. Around the front end is a white stripe. The sides of the top of the abdomen are bright orange and between the orange and black areas are three pairs of white spots. In the middle of the black area is a lighter stripe of yellowish iridescent scales which, in some lights, can not be easily seen, and may be absent altogether.

The epigynum has a round opening in front with the sides slightly darkened and toothed. The hinder notch is rounded but variable in shape. Pl. I, fig. 1*e*, 1*f*.

The male palpus has the tibial hook, small and sharp. Fig. 1*h*, 1*i*.

This is one of the most common Attidæ on plants throughout the summer. It matures in July and the males and females may be found together in a bag of silk among leaves, and in the same bag the female makes her cocoon of eggs, from which the young come out in August and become half grown before winter.

Mt. Washington and Dublin, N. H., Eastern Massachusetts, New Haven, Conn.

Phidippus brunneus, new sp.

This spider closely resembles *P. multiformis*, and I supposed it to be a variety of that species. The size is the same and it has indistinctly the same markings on the abdomen in some individuals. The differ-

ences are in the color and the epigynum. The color in life is reddish brown, covered with gray and black hairs and small gray scales not close enough to cover the skin. The cephalothorax is a little darker brown than the abdomen. The abdominal markings are indistinct in some individuals, and in most entirely absent. The legs are more uniformly colored than in *P. rufus*, the ends of the joints being less distinctly darkened. The epigynum, Pl. I, fig. 2, is more distinct than in *multiformis*, the dark thickened edges of the anterior opening are longer and the opening is divided in front by a thick brown middle line into two.

Salem and Waltham, Mass.

Phidippus ruber Keys not *P rufus* Peckham.

This species is known to me principally by the males. These are 6 or 7^{mm} long. The cephalothorax and abdomen are bright orange above and black beneath. The abdomen is covered with large orange scales lighter colored than those of the cephalothorax and mixed with the scales are long black hairs. On the hinder half of the abdomen are two distinct black longitudinal stripes in which are two pairs of white spots. Pl. XV, fig. 4. These markings vary in size and in one male are almost covered by orange scales. The femora of all the legs and tibia of first pair are black, the other joints orange brown, darker or black toward the tips. The male palpi have the tibial hook flat and round at the end. Fig. 4*b*, 4*c*.

The female which I suppose to belong to this species is 9^{mm} long. The abdomen is covered with orange yellow scales and black hairs finer and shorter than in the male. There are no black stripes. Around the front of the abdomen is a white stripe. The cephalothorax is brown covered with orange scales. The legs are orange brown, the front pair darkest and the femora of all the legs darker than the other joints, all of which are slightly darker toward the tip. The mandibles are brown in both sexes and not iridescent. The sternum of the female is dark, almost black, but the abdomen is as light beneath as it is above. The epigynum has two small openings. Fig. 4*ι*

Fem [illegible] Providence, R. I. Males, Topsfield, Mass., Sherborn, Mass., [illegible] Island near Manchester, Mass.

Phidippus mystaceus.

Attus mystaceus Hentz, ♀ *Phidippus albomaculatus* Keys, ♂ *P. purpuratus* Keys, *P. galathea* Peckham

The largest of the New England Attidæ, females measuring 12 to 15^{mm} long. The female is black, covered with gray hairs and scales closely enough to give the whole spider a gray color. On the abdomen are two longitudinal black stripes that do not extend quite to the front end and in these stripes are four pairs of bright white spots. The front end of the abdomen is crossed by a white band that extends back obliquely each side and at the sides of the abdomen are several oblique white stripes with black edges. Pl. XVI, fig. 3. The hairs of the palpi and front of the head under the eyes are longer and whiter than on other parts of the body. Under the abdomen is a middle dark line narrowing behind, on each side of which is a light gray border. At the sides of this are two wider dark bands and outside of them lighter gray. Legs gray, not ringed but a little darker toward the ends of the joints.

In alcohol the general color becomes dark brown and later reddish and all the markings are less distinct.

The male resembles the female but is darker colored. The cephalothorax, palpi and legs are black with a few scattered white scales and hairs. Abdomen black beneath. Back of abdomen with a greenish white border and a black area in the middle in which are four pairs of white spots.

The male palpus is large. The tarsal hook is nearly as long as the tarsus and sharp and slightly curved at the tip. Fig. 3*a*, 3*b*.

The epigynum has a hard plate with two small openings in front and a notch of various shapes behind. Fig. 3*c*, 3*d*.

It lives under stones at all seasons. In winter or when moulting or laying eggs it hides in a thick white bag of silk, in which the cocoons are made early in the summer. The young become nearly full grown before winter. Adult males are found from May to July and adult females at all seasons.

Common all over New England. Peckham has not found it in Wisconsin.

Phidippus tripunctatus.

Attus audax Hentz, *Attus tripunctatus* Hentz, *Phidippus morsitans* Peckham

A large female from Connecticut, measures 10^{mm} long and they are usually 8 to 9^{mm}. Peckham says western specimens are larger, often as long as 15^{mm}.

The color of both sexes is black, with black mixed with a few white hairs. The legs are gray in the middle of the joints and black toward the tips. The abdomen has a white band around the front and is marked with three large white spots, the middle one corresponding to the second pair in *multiformis* and *mystaceus* and the other two to the third pair. The other spots are generally present in this species but so small as not to be readily noticed. The under side of the body is black with two indistinct light stripes under the abdomen. The mandibles are metallic green and blue.

The males are 6 or 7^{mm} long and colored like the female. The mandibles have a short blunt tooth in front over the claw. Fig. 5*a*.

The male palpi have the tarsal hook pointed and turned downward. Fig. 5*c*. The palpal organ is wider at the base than in most species. Fig. 5*b*.

It lives under bark and stones, hibernating half grown in thick silk nests and concealing its egg cocoons in the same places. It is common all over the United States.

Dendryphantes æstivalis Peckham, 1883

D. capitatus Peckham, 1885 Resembles *Attus capitatus* and *parvus* Hentz.

Females 5 or 6^{mm} long and males smaller. There are two varieties in the colors of the females. The light variety, Pl. XVII, fig. 2, has the light parts white or light yellow and the dark parts dark brown covered with white hairs and scales. The cephalothorax is dark brown thinly covered with scales so that the dark color shows between them in spots. The legs are light yellow and translucent, indistinctly ringed with brown at the base, and near the tip of each joint all covered with greenish white hairs. The palpi are light and without rings except on the femur and patella. Abdomen brighter yellow than the thorax with four pairs of purplish brown spots, the second pair largest, connected with a paler brown middle marking. Abdomen beneath with a purple brown stripe in the middle and oblique brown stripes at the sides. Sternum, maxillæ and mandibles light brown. Scales smaller than those of the dark variety.

The dark variety, fig. 2*b*, is generally smaller and covered with longer hairs and scales. The legs and palpi are more distinctly ringed with dark brown. The dark spots on the abdomen are smaller and more connected by dark lines than in the other variety. The under side is dark brown.

In alcohol they become in a few days bright red in the darker parts which afterward fade and remain dull red for a long time. Both varieties in alcohol look much alike.

One of the most common Attidæ, living on plants, especially evergreen trees, all over New England.

The colors of the male, Fig. 2*c*, differ extremely from those of the female. The legs are ringed as in the female, but the brown parts are wider and not obscured by white hairs, while the white parts are whiter. The cephalothorax is dark brown with a white stripe each side under the eyes, bending toward each other behind but not connected. The front of the head is also white and covered with long white hairs. The palpi have the femur dark brown at the base and white at the end. The patella and tibia are brown and the tarsus is brown with white hairs on the upper side. The abdomen is white in front and around the sides. The middle is dark brown with a few yellow and greenish scales in the middle. The brown area is usually notched at the sides in four scallops and sometimes indistinctly divided in four pairs of spots as in the female.

In the female the cepalothorax is a third longer than wide and not much widened across the middle. In the male the cephalothorax is only slightly wider. The mandibles are vertical in both sexes and but little larger in the male than in the female.

The male palpi and the palpal organs are large in proportion to the size of the spider. The palpal organ extends back beyond the tibia. The tibial hook is very small. Fig. 2*e*. The tube of the palpal organ has a stiff point at its side a little longer than the tube itself. Fig. 2*d*.

The epigynum has the front opening small and divided into two directed sidewise. Fig. 2*f*.

Dendryphantes montanus, new sp.

Female 7^{mm} long, a little smaller than *militaris*, cephalothorax as long as in *militaris* but not as wide. Legs and mouth parts a little more slender than in *militaris*. The markings, as far as can be judged from specimens in alcohol, are like those of *militaris*.

The male has the cephalothorax nearly as wide as long. Pl. XVII, fig. 3*a*. The mandibles are as long as in *militaris* but not as stout, fig. 3*b*, and the palpi are as long and much stouter. The femora of the palpi are thickened towards the end, as in *æstivalis*, and the tibia and patella are very short. The palpal organ is long, and the tube long and stout. Figs. 3*d*, 3*e*. The epigynum, fig. 3*c*, has a single round opening, and a notch of various shapes, like *æstivalis*.

Mt. Washington, N. H.

Dendryphantes militaris.

Attus militaris Hentz. *Philæus militaris* Peckham.

Female 7 or 8^{mm} long. The cephalothorax is wide across the middle in both sexes, nearly as wide as long. The middle eyes are a little nearer the front lateral than the dorsal eyes. The mandibles are a little flattened in front, and in the male, the front outer corner over the claw is sharp. Pl. XVII, fig. 1*a*.

The general color is brown, covered with black, and a few gray hairs, darker and browner than *æstivalis*. In alcohol it turns red but not so bright as *æstivalis*. The cephalothorax is brown in the female, and in the male the same color, with a white stripe each side under the eyes. Fig. 1*a*. The abdomen of the female is brown, with four pairs of white, oblique marks in the middle, and four at the sides. Fig. 1. The front of the abdomen is white. In the male the middle white spots are absent, and the lateral and front white marks are united into a band that extends nearly around the abdomen. Fig. 1*a*.

The palpi of both sexes are very slender, and the tarsi and palpal organs of the male are unusually small for so large a spider. The tube of the palpal organs is longer than in *æstivalis* and more simple. Fig. 1*d*.

The mandibles of the male are widened at the end, and have a large two-pointed tooth near the end of the claw. The claw has a short, flat tooth on the inner side, near the middle. Fig. 1*b*, 1*c*. The epigynum is like that of *æstivalis*, but the opening is wider.

Zygoballus bettini Peckham

A larger and more slender species than *terrestris*. The body is higher and narrower, the legs and palpi are larger, and the complicated mandibles of the male are larger in proportion to their thickness. The cephalothorax is almost as high in the middle as it is wide, and slopes from the hinder eyes steeply backward. Toward the front the slope is less, and the front of the head is half as high as the hind pair of eyes. Pl. XVII, fig. 4. The abdomen is rounded above and widest across the hinder half.

In life, the colors are bronze green and yellow, marked with white. In alcohol the cephalothorax is dark brown with whitish scales. The abdomen is lighter brown, sometimes reddish, especially in specimens not long preserved, with white markings sometimes forming a regular herring-bone figure in the middle, and sometimes broken

into irregular dark and light spots. Around the front is a white band, and there are other slanting white stripes along the sides.

The femur of the first pair of legs is very dark brown, the other joints white. The second and third legs are white, or only slightly darker at the ends of the joints. The fourth legs have the hinder half of the coxæ, and the ends of all the joints brown.

In the male the legs and palpi are brown, without the distinct dark markings of the female. The abdomen is brown with irridescent greenish scales, and a bright, white band around the front, and two white oblique stripes each side.

The male has the front legs much larger than the female His mandibles are long and stout at the base, and spread apart at the ends. In the middle of the inner side is a large tooth, directed downward, and near its base, two smaller ones, on the under side of the mandible. On the under side, near the outer edge, is a long ridge, ending in a tooth, curved inward. Fig. 4*a* The male palpi are very slender, and the tarsus and palpal organ long and small. The patella and tibia are each twice as long as thick. The tibial hook is nearly as long as the tibia Fig. 4*b*.

Common on plants in summer, and occasionally found under stones and bark.

· Massachusetts and Connecticut.

Zygoballus terrestris, new sp

Length of female 3^{mm}. The cephalothorax is two-thirds as wide as long, and half as high as long. The posterior eyes are the full width of the cephalothorax apart, and the thorax slopes backward from them, but not as steeply as in *bettini*, nor is it as much narrowed behind. Pl. XVII, fig. 5.

The color of the cephalothorax in alcohol, is dark brown, covered thinly with small, light colored scales. The first pair of legs are dark brown, the femur darkest, and the other joints a little lighter in the middle. The other legs are lighter with the ends of the joints dark. Fig. 5*c*. The abdomen is lighter than the thorax, and marked with irregular and variable dark spots.

In the male the abdomen is brown in the middle, with a distinct white line around the front and sides. The male palpi are short, the patella and tibia being not much longer than wide. The tibial hook is as long as the tibia itself, and only slightly curved. Fig. 5*d*. The palpal organ is small and covered by the tarsus. The tube is moderately long, and lies in the groove at the end of the tarsus for

its whole length. The mandibles are similar to those of *bettini*, but smaller. The epigynum has the anterior opening nearly square, opening toward the front, and the posterior notch very wide. Fig. 5*b*.

On fences and under leaves in winter.

Boston and Cambridge, Mass., and New Haven, Conn.

Icius mitratus Peckham

Attus mitratus Hentz

This species resembles closely *palmarum*, differing mainly in color. The legs are all white in both sexes, and the mandibles of the male are not long and horizontal as in *palmarum*. The male palpi and palpal organs are like those of *palmarum*, with the tibial hook perhaps a little more slender. The female preserved in alcohol is still more like *palmarum*. The epigynum is of the same shape and the markings in four large spots on the abdomen, like those of some females of *palmarum*. The cephalothorax seems to be a little wider, and the colors of the hairs of the whole body whiter than in *palmarum*.

A living male has the legs white, or a little greenish, with long white hairs, those on the front legs longer than the diameter of the leg. On the front of the leg and palpi are long, white hairs. The sides of the cephalothorax and abdomen, and the under side of the abdomen are white. The middle of the cephalothorax and abdomen are light brown, covered with light, yellow hairs, through which three or four dark spots show indistinctly. Pl. XVIII, fig. 2.

Brookline and Malden, Mass., and New Haven, Conn.

Icius palmarum Peckham.

Epiblemum palmarum Hentz

Female 5^{mm} and male 4^{mm} long. The living female has the legs and palpi transparent white, and the claws black. The few spines on the legs are black. The whole body is covered with light gray or white scales, mixed with short, fine black hairs. The abdomen has a row of indistinct, darker triangular spots in the middle and oblique rows of small spots at the sides. Pl. XVII, fig. 1. In alcohol the legs become dull yellow, and the rest of the body turns red as in *æstivalis*, afterwards fading to a dirty yellow. The markings of the abdomen become more distinct, and in some individuals form four large, dark brown spots. Fig. 1*f*.

The living males, fig. 1*g*, have the front legs very dark brown, except the tarsi, which are a little lighter. The other legs are transparent white, cephalothorax and abdomen dark and reddish brown, mixed with shining, greenish white scales, and sometimes a little copper red around the eyes. There is a white stripe the whole length of the body, each side, and across the front of the head below the eyes. The maxillæ and mandibles are dark brown, and the palpi are the same color, except the tarsi which are light yellow ; sternum and under side of abdomen dark brown. Some males show indistinctly dorsal markings of the abdomen, like the female.

The female resembles *æstivalis*, but is longer in proportion to its width and has the front legs stouter. The abdomen is usually nearly twice as long as wide. Fig. 1. The cephalothorax is flattened above from the front eyes two-thirds its length backward, in both sexes, fig. 1*a*, while in *æstivalis* it is slightly arched upward.

In the males, the front legs are, as usual, longer and stouter than the others and are made very conspicuous by their dark color. The mandibles of the male are larger than those of the female, and more or less turned forward, according to their length. In some males the mandibles are only a little longer than those of the female, and in these the patella and tibia of the front legs are not much longer than the femur. Others, usually larger spiders, have the mandibles nearly as long as the cephalothorax and extending forward horizontally, the maxillæ are longer, and the first pair of legs have the patella and tibia one and a half times as long as the femur. Fig. 1*c*. Fig. 1*g* shows the mandibles of the common length.

The epigynum has two small anterior openings and a large, wide notch behind, half-way between the anterior openings and the transverse fold.

The male palpus has the tibia as wide as long, and the patella a little longer. The tibial hook is as long at the joint itself, thin and curved inward a little at the end. The tube of the palpal organ is long and curved around the end of the bulb, the point resting in a groove turned obliquely outward on the end of the tarsus. Figs. 1*h*, 1*i*.

On plants in summer. Massachusetts and Connecticut.

Icius elegans, ♀ *Attus elegans* Hentz ♂ *Attus superciliosus* Hentz

Dendryphantes elegans Peckham.

Female 6^{mm} long. Cephalothorax two-thirds as wide as long, and abdomen half as wide as long. The sides of the cephalothorax are

nearly straight and parallel in the female, and widened a little behind the middle in the male.

The colors of the living female, Pl. XVIII, fig. 3, are bronze green, which in some lights changes to copper red on the abdomen and cephalothorax. The legs are yellow, with longitudinal dark stripes, except the front femora, which are dark brown. The palpi are bright yellow at the end and dark at the base. In alcohol the colors appear dull and darker.

The males, fig. 3*d*, are much more brightly colored. The legs are orange, darker toward the ends, with fine dark, longitudinal stripes. The ends of the front tibiæ are dark brown, and have long, brown hairs on the inner and under side. The palpi are orange, darker toward the end. The sides and hinder part of the cephalothorax are orange, and there is a white line each side over the coxæ. The upper part of the cephalothorax and abdomen are covered with greenish yellow scales. On the front of the head are tufts of long hairs, yellow, mixed with black, pointing forward and a little inward between the middle and lateral eyes, fig. 3*e*. On the hinder end of the abdomen is an iridescent purple spot. The abdomen is green on the under side, and the sternum and coxæ are orange. In alcohol the colors become dull yellow and brown.

The mandibles of this species are slender, and the claw short, and strongly curved inward toward the point. In the male the mandibles are a little longer, and have a slight notch on the inner side, one-third their length from the end. Fig. 3*e*.

The epigynum is wide, with two anterior openings more than their diameter apart, and the posterior notch is divided into two. Fig. 3*h*.

The male palpi have the patella as wide as long, and the tibia still shorter, with a very short and small hook on the outer side. Fig. 3*g*. The tube of the palpal organ is twisted at the end, and has a spherical base, partly covered by the softer part of the bulb. Fig. 3*f*. The male has the legs of the first pair much larger than the others, and all the legs longer than the female. In the female the fourth legs are longest.

Some males have the colors darker and the front legs less elongated than usual, and do not have the black spot and black tuft of longer hairs on the ends of the tibiæ. They also have the tufts of hair over the eyes much smaller. Figs. 4, 4*a*. The palpal organs are a little stouter. Figs. 4*b*, 4*c*. Specimens from the Adirondacks and White Mountains are of this variety.

White Mountains, N. H., to New Haven, Conn.

Icius hartii, new sp.

The name *Icius Hartii* was given this species by Mr. Peckham, but not published. A specimen in the Museum of Comparative Zoology in Cambridge, is named by Keyserling *Icius tibialis* Koch.

Of this species I have only one female from Medford, Mass. This is 7^{mm} long, cephalothorax 2^{mm} long, and 1^{mm} wide. The cephalothorax is straight at the sides, very little narrowed behind. The abdomen is oval, a little pointed behind. Pl. XVIII, fig. 5. The length of the legs is 4, 1, 2, 3. The front legs are thickest, and the tibia is more than twice as thick as that of the other legs. In the male, fig. 5*a*, the front legs are longest and still more thickened than in the female. The cephalothorax is dark brown, with gray hairs. The abdomen has the middle dark and the border white; the middle area broken at the edges by three or four pairs of white spots. The under side of the abdomen is light in the middle and black around the edges up to the white border of the upper surface. The femora are dark, except the third pair, which has light stripes. The other joints are dark at the ends, and have dark longitudinal stripes. The epigynum is small, and has two small openings directed forward about their diameter apart. Fig. 5*d*.

Some of the Wisconsin specimens which I have from Mr. Peckham, are a little larger, and the dorsal markings are more broken by oblique rows of white spots. The males have the abdomen shorter and the front legs much longer and thicker. The mandibles are a little longer than in the females. The male palpi are short and stout, the patella and tibia are as short as wide, and the tibial hook is very small and pointed, and directed downward. Fig. 5*c*.

The palpal organ is long enough to nearly cover the tibia. The tube is short and stout, and a little swelled at the base. Fig. 5*b*.

Icius formicarius, n. sp.

Length 5^{mm}. Cephalothorax and abdomen usually about the same length. The general appearance is ant-like. The color is black with dark bronze green scales, except a white line each side of the thorax, and white stripes on the legs, two above and one beneath. One specimen has a few white scales on the spinnerets.

The cephalothorax is two-thirds as wide as long and the sides are nearly straight and parallel. The abdomen is widest across the hinder half and a little pointed behind. Both cephalothorax and abdomen are less flattened than in the other species. The legs are

long and slender, the fourth pair longest and the first next. The first pair are only a little stouter than the others. Pl. XVII, fig. 6. The epigynum is large with the anterior openings wide and far apart. The notch behind is very deep and narrow. Fig. 6*b*.

I have seen females only from Salem and Medford, Mass., and New Haven, Conn.

Mævia vittata.

Astia vittata Peckham, *Attus vittatus* Hentz, *Attus niger* Hentz. ♂ *Mævia pencillata* Koch

This is a large and brightly colored spider with long legs. The female is 8mm long, the male smaller but with the legs longer. Pl. XIX, figs. 1, 1*a*, 1*b*.

The living female has the legs and palpi translucent, a little yellow or greenish white. They are marked with indistinct light gray rings and black spots at the base of the hairs and spines. The cephalothorax is dark brown between the eyes and translucent like the legs in the thoracic part. There is a fine black line in the middle and on each side and a few gray marks radiating from the dorsal groove. The whole top of the cephalothorax is covered with greenish yellow scales mixed with gray hairs. The eyes are black and one female has a red stripe under the eyes each side. The abdomen is covered with scales which in the middle and at the sides are gray and mixed with black hairs. There are two longitudinal bands of light copper red along the back of the abdomen and indistinct angular marks of the same color in the middle of the hinder half. The colors of the under side are light gray and yellow spotted with gray on the abdomen.

According to Peckham, males of two very different colors belong to this species. One kind resembles the female. Fig. 1*b*. The red bands on the abdomen are broken up into rows of spots connected with the middle angular markings. The gray and black spots on the legs and cephalothorax are larger and there are several black marks on the front of the abdomen.

The palpi are bright orange yellow with the tibial hook black and a black spot on the inner side of each joint. The size of the black spot varies in different individuals and so passes into the other variety in which the cephalothorax and abdomen are entirely black and the palpi black except a few orange hairs on the outer side. The black cephalothorax and abdomen are covered with dark greenish shiny scales. The legs in this variety are white except the hairs. On the

front of the head of the black variety are three tufts of long hairs which are entirely wanting in lighter colored males. Fig. 1*a*. Although males of both kinds pair with the same female their behavior when mating is different, for an account of which see Peckham's article in Occasional Papers of the Nat. Hist. Soc. of Wisconsin, vol. i, 1888.

The cephalothorax of the female is widest behind the middle and is there two thirds as wide as long. It is narrowed to half that width at the hinder end and slightly narrowed toward the front, the head being not much more than half as wide as the cephalothorax is long. Fig. 1. The top of the cephalothorax is flat, rising a little between the dorsal eyes and the front row of eyes is straight on the upper edge. The comparative length of the legs is 4, 1, 3, 2 and the fourth pair is as long as the body.

The male palpi are long. The tibial hook is straight and blunt and about as long as the tibia itself. The tarsus is short and wide and turned outward at the tip. The palpal organ is oval with a long tube bent around the end of the bulb with its point in the groove on the outer corner of the tarsus. Fig. 1c.

The epigynum has a small oval opening very far farward and a slight notch on the edge of the transverse fold. Fig. 1*d*.

This is an active species, living on plants in summer.

Eastern Massachusetts and New Haven and Meriden, Connecticut.

Marptusa familiaris Peckham

Attus familiaris Hentz.

The female is 10^{mm} long and the male nearly as large. The fourth pair of legs is longest in the female and the first pair in the male. The cephalothorax and abdomen are both much flattened. The cephalothorax is rounded at the sides and nearly twice as wide in the middle as in front. The abdomen is twice as long as wide, widest in the middle and truncated at the front end and sometimes at the hinder end also. In the latter case the spinnerets are so far under the abdomen that they cannot be seen from above. The legs are long and stout, the fourth pair one and a half times as long as the abdomen.

The general color is gray, covered with long gray and white hairs. The cephalothorax has a dark brown band along the edge each side which is larger and darker in the males. The abdomen has in the middle a yellowish white marking, covering half its width, the front half straight and the hinder half notched at the sides. Pl. XIX, fig.

3. The legs are darker at the ends of the joints and lighter in the middle. The under side of the abdomen is light at the sides and has a dark stripe in the middle.

The male palpus has the tibia very short and the tibial hook is long and slender and slightly thickened at the tip. The tube of the palpal organ starts from the middle of the inner side of the bulb and turns obliquely across the end of the tarsus. Near the end of the tube but not quite reaching the tip is a short flat process. Figs. 3*b*, 3*c*.

Epiblemum scenicum Thorell *Epiblemum faustum* Hentz. *Salticus scenicus* Latr *Calliethera scenica* Simon *Epiblemum scenicum* Peckham

Gray with white markings. On some the white marks are much more definite than on others, the gray ground having very few white scales mixed with it. I have usually found the spiders of this variety about houses, while those from the country, living on plants, have white as well as yellow scales largely mixed with the gray so as to obscure the white markings. The field specimens are usually more slender.

The front of the head around and above the eyes is white. There is a definite white stripe on each side of the cephalothorax and in the middle of the cephalothorax two white spots one on each side of the dorsal groove. On the abdomen there is a white stripe across the anterior end and two oblique marks on each side. Pl. XIX, fig. 2.

The legs are gray with white rings not very distinctly marked and the palpi white. The markings are very different from those of any other species.

The proportions of the body differ considerably in individuals, some appearing much longer and more slender than others. The cephalothorax is about two-thirds as wide as long and the abdomen usually about the same width and longer.

The epigynum is raised at the hinder edge, a little pointed and with a round notch about as deep as wide. The anterior half is a little narrowed and notched in the middle with a depression on each side, in the bottom of which is a round hole. Fig. 2*e*. The shape of the epigynum varies and in pale or freshly moulted females the internal parts may be seen through the skin as shown in Peckham's figure.

The males differ but little in color and markings from the females, but the palpi are large and the mandibles two-thirds as long as the cephalothorax and turned forward almost horizontally. Fig. 2*a*, 2*c*.

The tibia of the male palpus is shorter than the patella and at the distal end as wide as long, with a stout pointed hook directed forward and a little inward. Fig. *2f*.

Found occasionally under stones or on bushes but common on the outside of houses and fences in the warmest and driest places. The colors resemble closely that of unpainted wood stained by the weather.

Common all over New England. A common European species.

Menemerus lineatus. *Icius lineatus* Peckham *Attus quadrilineatus* Peckham, 1883

A small spider only 4^{mm} long and very distinctly marked with two white longitudinal lines on the middle of the abdomen and two others on the sides so far down that only the front ends of them can be seen from above. Pl. XIX, fig. 5.

The color in life is dark brown. The white lines on the back have their edges very dark. The cephalothorax and dark parts of the abdomen are thinly covered with long, slender, yellow scales mixed with a few white hairs on the front of the abdomen. On the under side of the abdomen are four white lines. The legs are dark brown, the first pair darkest.

The relative length of the legs is 1, 4, 2, 3. The first pair are twice as thick as the others. The top of the cephalothorax is flat two-thirds its length from the front. There is a short, transverse groove a little behind the dorsal eyes. The cephalothorax is widest across the middle but only very little wider than in front. The epigynum has a dark ridge behind, curved at the ends around two round holes. Fig. *5b*.

Manchester and Medford, Mass.

Menemerus binus. *Attus binus* Hentz, not *M paykullii* Peckham, 1883

Female 9^{mm} long. Legs 1, 4, 2, 3, The cephalothorax is widest behind the middle and narrows slightly toward the front of the head where it is half as wide as long. The cephalothorax is flat above and a little swelled around the dorsal eyes. There is a short transverse groove behind the eyes. Pl. XIX, fig. 4.

The abdomen is half as wide as long, narrowed at both ends. The first pair of legs are about as long as the fourth pair, but twice as thick. The second pair of legs are slightly thicker than the third and fourth.

I have not seen the colors in life. In alcohol the cephalothorax is dark brown except around the edges where it is yellowish. The front half of the cephalothorax between the eyes is dark purple when turned to the light. The abdomen is white with two longitudinal black stripes that do not reach either end. The front legs are orange color with light brown stripes and a black spot near the end of each joint on the inner side. The other legs are dirty yellow with indistinct brownish stripes at the sides. Under the abdomen is a black middle stripe.

The epigynum has the openings very small and wide apart and the posterior notch very wide with square corners at the ends. Fig. 4*a*.

One female from Meriden, Conn. Mr. Peckham has the same species from Nebraska.

Neon nellii Peckham

This is the smallest of our New England Attidæ, being only 2.5 to 3^{mm} long with the cephalothorax not much over 1^{mm}. The general color is dark gray, darkest toward the head, so that the spider is hard to see on gray stones or weathered wood. The cephalothorax is high, the highest part being a little behind the middle, from which it curves downward to the front eyes and slopes more abruptly backward. The eyes are large and prominent, the first row nearly straight and as wide as the widest part of the cephalothorax. The posterior eyes are nearly as large as the front middle pair and are at the middle of the cephalothorax. The abdomen is a little pointed behind and the spinnerets are large for the size of the spider. Pl. XX, fig. 1.

The cephalothorax is smoky gray, darker toward the front and darker in the males than females. The abdomen is gray with yellowish white markings in a herring-bone pattern through the middle. The underside of the body is light gray or whitish. The legs are gray, darker toward the front.

The epigynum is large and has two rounded openings toward the front. Fig. 1*b*. The male palpi are also large and the palpal organ extends backward so as to cover the short tibia. The tube lies obliquely across the end of the bulb, its tip resting in a groove on the end of the tarsus. Fig. 1c.

A common species under stones and leaves at all seasons.

Euophrys monadnock, new sp.

One male was found on the upper part of Mt. Monadnock, N. H., on the rocks. Pl. XX, fig. 2. It is 4^{mm} long, the cephalothorax and abdomen about the same length. The legs are all long, relative length 4, 1, 3, 2. The ends of the palpi are white as far as the end of the femur. The tarsi of the first and second legs, and the tips of the tarsi of the third and fourth are white. The femora of the third and fourth legs are white, in life, light pink. The rest of the body is deep black. The first and second legs are a little thickened and the metatarsus, tibia and patella, and the end of first femur covered with long scales, as long as the diameter of the leg. The first and second legs are bright purple toward a bright light.

The front of the head is wide, and the sides of the cephalothorax nearly straight and parallel. Fig. 2*c*. The front of the head, below the eyes, slopes inward, and the sternum is short and wide. Fig. 2*a*.

The palpi are long and slender, the tarsus not much wider than the other joints. The tibial hook is straight and very slender, not much thicker than one of the hairs. Fig. 2*d*. The palpal organ is long and narrow at the base, where it extends over the tibia. The tube is short and curved around the end of the bulb. Fig. 2*e*.

A female, which probably belongs to this species, was found in Dublin, N. H., three miles from Monadnock. It is 5^{mm} long, with short and thin hairs and colors like *Tegenaria*. The cephalothorax has the sides straight and parallel, three-fourths its length from the front, and is a little rounded behind. Fig. 2*f*. The eyes are large and the lateral are more than half as large as the front pair. The posterior eyes are as far apart as the length of the front row, and little more than half as far from the lateral. The abdomen is oval, widest behind the middle. The legs are 4, 1, 2, 3, the front pair much thickened and the second slightly so. The cephalothorax is dark brown in front and lighter toward the back, marked with dark radiating lines. The abdomen is gray, with light, angular markings along the middle, and irregular oblique lines at the sides. The legs are without markings, the first pair darkest. The epigynum has two large openings about their diameter from the transverse fold. Fig. 2*g*.

Euophrys cruciatus, new sp.

This species is more generally covered with scales than *monadnock*, the front tibiæ are less thickened, and do not have the long

scales of that species, and the colors are less bright and more like those of *Attus palustris*. The only specimen I have, a male, is 5^{mm} long. Pl. XX, fig. 8. The cephalothorax is three-fourths as wide as long, widest behind the middle. It is low in front, and the front row of eyes are turned a little downward, the lateral pair half their diameter, higher and farther back. The middle eyes are nearer the dorsal than lateral. The dorsal eyes are nearer together than the lateral pair. The abdomen is as long and as wide as the cephalothorax, widest in the middle and pointed behind.

The lengths of the legs are 4, 1, 3, 2, the fourth pair very long. The first and second pairs are a little thickened.

The cephalothorax of my specimen is so much rubbed that the markings are nearly destroyed; it shows only long black hairs over the eyes, and irregular white markings behind the eyes and at the sides. The abdomen is black, with a distinct white cross in the middle. Fig. 8. The legs have dark and light rings, which were probably covered with white and black hairs. The tibia of the palpi is light, and the other joints dark, with long hairs.

The tibia of the male palpus is wider than long. The tibial hook is nearly as long as the tarsus, and curved to fit along its edge. The tarsus is strongly curved downward. The palpal organ is oval, and the tube begins near the outer end, curves around its base and again outward through a groove in the edge of the tarsus to a notch near the end of the tibial hook. Figs. 8*b*, 8*c*, 8*d*.

Dublin, N. H., July 16.

Phlegra leopardus. *Attus leopardus* Hentz.

Very distinctly marked with two white lines on the cephalothorax, as far up as the dorsal eyes, and three white lines on the abdomen. The female is 8^{mm} long, the cephalothorax 3.5^{mm}. The cepholothorax is two-thirds as wide as long and a little widest behind the middle. The lateral front eyes are high enough for their middle to be opposite the top of the middle eyes. The dorsal eyes are unusually far forward; they are as far apart as the front lateral eyes, and two-thirds as far from the front of the head. Pl. XXI, fig. 1. The cephalothorax is rounded upward from the front to the dorsal eyes, and from there backward is flat more than half-way to the hinder end. The abdomen is widest in the middle and a little pointed behind. The legs are short, and their relative length 4, 3, 1, 2. The first and second pairs are thicker than the other. The cephalothorax is dark brown, darkest between the eyes. A white stripe extends

from the front of the head, over the eyes each side the whole length of the cephalothorax. A middle white stripe begins between the middle eyes, but fades out between the dorsal eyes. The legs are light brown, with two darker rings on each joint. The abdomen is brown, with a middle and two lateral white stripes. The abdomen is light on the under side and the sternum, legs and mouth parts dark brown. The epigynum has two large round openings near the hinder edge, and a small, square-cornered notch in the edge. Fig. 1*b*.

The male is darker than the female, but marked in the same way on the cephalothorax and abdomen. The white bands on the cephalothorax are mixed with red between the eyes. The legs are longer than those of the female, and not marked with rings.

The male palpus has the tibia short and wide on the upper side, with a deep notch on the outer side, and a short hook. Figs. 1*c*, 1*e*. The bulb of the palpal organ extends backward on the outer side so as to cover the tibia. Fig. 1*d*.

Female from Mt. Tom, Massachusetts. Male from Blue Hill, Milton, Mass. Another female was seen in Medford, Mass.

Hasarius Hoyi, Peckham.

Female 6 or 7^{mm} long. The cephalothorax is shorter and the abdomen larger than in the nearest species. Pl. XXI, fig. 2, 2*a*. The cephalothorax of the female is three-fourths as wide as long, and a little enlarged in the middle. The posterior eyes are two-thirds as far from the front row as from each other. Legs 1, 4, 2, 3, all nearly of the same length. First and second pairs a little thickened.

The markings vary, but in alcohol there is always a light marking across the back of the cephalothorax, a little behind the dorsal eyes, and turning forward on each side as far as the front eyes. In front and behind this marking the cephalothorax is dark brown. On the abdomen there are light and dark oblique markings forming, especially in young individuals, a regular light herring-bone marking in the middle.

In life, the light markings are partly white and partly orange-brown. A brightly marked young male has the cephalothorax white in front, both above and below the eyes. Fig. 2. A white band on each side turning upward and inward behind the dorsal eyes, but not united in the middle. Hinder part of cephalothorax below and between the white bands black. There are two black bands behind the dorsal eyes, extending obliquely through the dorsal groove to the white

bands at the sides. The rest of the top of the cephalothorax is covered with orange scales.

Abdomen with a white band around the front and sides. Middle of the back black, with a few orange scales around the edges. Sides of the black patch irregularly scalloped. In the middle are oblique white markings, edged with orange-brown.

The legs are white at the ends and dark on the patella and tibia, and outer end of the femur. Ends of all the joints darker than the middle.

The epigynum has two large anterior openings near together, and behind and each side of them two other large openings near the edge. Fig. 2*e*.

The adult male has the colors much like the young male, described above, with the legs black on the patella and tibia, and part of the femur, and the rest white, with black at the ends of the tarsus and metatarsus. The female is various shades of brown, mixed with white and yellow scales and black hairs. Fig. 2*b*, 2*c*.

The male palpi are short, black at the base and white on the top of the tarsus. The tibial hook is long and blunt, extending along the side of the tarsus half its length. Fig. 2*f*, 2*g*. The palpal organ has the inner posterior corner swelled and extended inward to a blunt point. Fig. 2*f*. The tube curves around from the base to the tip of the tarsus.

A common species in eastern Massachusetts. Found also from the White Mountains to southern Connecticut.

Habrocestum splendens, Peckham ♂ *Ergane splendens* Keys.
♀ *Pellenes nigriceps* Keys

I have only seen the males of this species. It has been fully described by Peckham in his N. A. Attidæ in the Transactions of the Wisconsin Academy, vol. vii, and figured and its mating habits described in vol. i, of Occasional Papers of the Nat. Hist. Society of Wisconsin, Milwaukee, 1889.

My males are 5^{mm} long, with the cephalothorax nearly 3^{mm}. The cephalothorax is widest and highest behind the second legs. The front part projects forward beyond the mandibles and the front eyes look a little downward. Pl. XX, figs. 5, 5*b*. The abdomen is shorter than the cephalothorax, widest in the middle, square in front and pointed behind. The legs are long and stout, the third pair longest. In alcohol the brilliant colors of the male fade, and the colors and markings resemble more those of the female. The cephalothorax is

dark brown, with a transverse light marking behind the eyes. The whole cephalothorax is thickly covered with light scales, and the front half with black hairs between them. The legs and palpi are light at the base and darker brown toward the tips, covered with scales and hairs, either black or various shades of gray. The abdomen is marked with three or four pairs of dark spots, united together more or less in different spiders, the front pair usually forming a single transverse mark, with a light mark in front of it. The light portions of the abdomen are yellowish in the middle, and bright copper-red at the sides.

The male palpi have the femur long, the patella about as long as wide, and the tibia half as long as wide. The tibial hook is large and flat, fig. 5*d*, and lies against the tarsus, nearly half its length. The tarsus is short and wide, and the bulb of the palpal organ flat and circular. The tube starts at the base and curves around the inner side, ending in a short groove, pointing outward on the end of the tarsus. Fig. 5*c*.

Beverly, Mass. Clarksville, near Albany, N. Y. Young in winter in old cocoons of *Argiope*, on marshes between Boston and Brookline, Mass.

Habrocestum peregrinum, Peckham

These specimens have been identified for me by Mr. Peckham.

The female is 6^{mm} long, the male a little smaller ; both sexes smaller than *H. splendens*. The area between the eyes slopes forward and is covered with short scales mixed with longer hairs, light brown in front and darker behind, where it meets a white marking pointed forward in the middle and curved backward and outward behind the eyes. Pl. XX, fig. 6. On each side of the cephalothorax is a white stripe, extending from the front lateral eyes backward under the eyes, and then curved upward and again downward to the end of the thorax. The abdomen has three white stripes, with black between, narrower and sharper in the male. The under side of the body and legs are light brown, with white and black hairs.

The legs of the third pair are very long in both sexes, and in the male there is a peculiar shape to the patella, fig. 6*b*, which is flattened and widened at the distal end, where there is a stout spine extending over the tibia. On the front of this flattened patella is a black spot. Mr. Peckam gives an account of the use of this ornamental patella in the pairing of an allied species in "Occasional Papers of the Nat. Hist. Soc. of Wisconsin, vol. i, No. 3, 1890." Peck-

ham's description says, two short spines on tibia of first pair, but my male has three pairs of spines on tibia and two pairs on metatarsus.

The male palpus differs little from that of *splendens*. The tibial hook is a little sharper, and the angle of the tarsus just over it, a little more prominent

The epigynum has a simple round opening directed forward, from which a tube extends backward. Fig. 6*a*

I have only three specimens—an adult male and female, and one immature male from Hyde Park, Mass. Mr. Peckham has it from New York and Connecticut.

Saitis pulex, Peckham

Attus pulex Hentz. *Saitis X-notata* Keyserling *Cyrba pulex* Keyserling.

A common spider 4 or 5^{mm} long, the female gray or brown of different shades, and resembling gray stone or dried leaves, on which it lives. The cephalothorax and abdomen are of the same length, the abdomen of the female wider than the cephalothorax, widest across the middle and pointed behind. Pl. XX, fig. 7*a*. The cephalothorax is half longer than wide, widest behind the middle. The eye-space is half wider than long, narrower behind than in front. The third and fourth pairs of legs are of the same length, and longer than the first and second. The cephalothorax has a light stripe in the middle, between the eyes, that narrows backward to a point at the hinder end. The abdomen has two nearly parallel light lines in the middle of the front half and behind them a transverse marking pointed at the sides, behind and around which are small, irregular light marks. The legs are covered with alternate dark and light spots.

The epigynum has two large openings near together, and near its hinder edge. Fig. 7*g*.

In the male the abdomen is smaller and narrower, the head higher and the colors brighter. Fig. 7. The cephalothorax, between the eyes and a little behind them, is black. The front and sides of the head below the eyes, and the hinder half of the cephalothorax are yellow, or orange. The abdomen is black with markings like the female. The legs have the tarsi yellow and the other joints indistinctly marked with longitudinal yellow lines. The palpi are yellow, except the ends of the tarsi which are black. On the under-side the legs and abdomen are black. The coxæ are yellow, with a black line in the middle and the sternum, maxillæ and mandibles are yellow; the sternum sometimes with a black middle line. The male palpi

have the tibia very short, with a flat, thin hook. Fig. 7*c*, 7*d*. The tube of the palpal organ is short and curved in a circle on the end of the bulb so that the tip points inward. Fig. 7*e*.

Massachusetts and Connecticut.

Attus palustris, Peckham

Female 6^{mm} long, male 5^{mm}. The cephalothorax is three-fourths as wide as long. The abdomen is short, a little wider than the cephalothorax and pointed behind. Pl. XX, fig. 3. The cephalothorax is light brown in the female and dark in the male, with a narrow, white stripe in the middle, widened between the dorsal eyes, and a white stripe each side, as high as the dorsal eyes. The abdomen has a wide, white transverse marking, just behind the middle, and several angular marks behind it. On the front half are two white spots. In the male the large middle marking is usually divided into two white spots.

The relative length of the legs is 4, 1, 2, 3 in the female, and 1, 4, 2, 3 in the male. The dorsal eyes are very far forward, little more than half as far from the front eyes as they are from each other.

The epigynum has a large oval opening divided in front into two. The hinder edge over the transverse fold has a small projection in the middle. Fig. 3*c*.

The hook of the tibia of the male palpus is nearly straight and has a short piece at the tip very narrow. Fig. 3*b*. The palpal organ is oval, and the tube extends from the base around the inner side, the end pointing outward. Fig. 3*a*.

Portland, Me.; Eastern Mass.; New Haven, Conn.

Attus sylvestris, new sp.

Male 4^{mm} long. Cephalothorax almost as wide as long. Abdomen smaller than cephalothorax; legs shorter and stouter than in *A. palustris*, and the male palpi nearly as large as in the male *palustris*, which is half larger. The colors resemble those of *Saitis pulex*. The legs are distinctly ringed with dark and light brown. The cephalothorax is dark brown, covered with lighter hairs, which are nearly rubbed off in the specimens. The male palpi have the tarsus dark brown, and the rest of the palpus lighter above but dark beneath. The tibia and patella are covered with white hairs that are very long on the sides of the tibia. The palpal organ resembles closely that of *A. palustris*, and is nearly as large. The markings

of the abdomen are dark and light brown, and resemble those of *Saitis pulex* and the female *A palustris.* There is a large light mark across the middle of the abdomen, and behind it several light angular marks. In colors and general appearance this resembles *Saitis pulex*, and lives in the same places under stones and leaves.

Beverly and Middleton, Massachusetts

Synemosyna formica, Hentz

This is the most common ant-like spider, and the most ant-like among them. It is 6^{mm} long, and the cephalothorax is 2^{mm} long and 1^{mm} wide The cephalothorax is narrowed behind and the abdomen in front and each has a deep depression near the middle. Pl XXI, fig 5. The pedicel of the abdomen is flat and widened behind, so that it is nearly as wide as the ends of the thorax and abdomen which it connects. The front middle eyes are large, and cover two-thirds of the front of the head The rest of the eyes are very small The legs are slender, their relative length 4, 3, 1, 2 The general color is black, with yellowish white markings There is a triangular white spot in front of the dorsal groove, and one on each side widening downward, under the posterior eyes. On the abdomen there is a white stripe extending downward from the dorsal groove on each side, and uniting in a large white patch on the front of the under side of the abdomen The second legs are entirely white, the first have a black stripe along the inner side, the third have the femur black and a black spot at the base of the tibia, and the fourth have the femur, the end of the patella and nearly all the tibia black, and black spots on the front of the coxæ and trochanter, and black lines on the metatarsus. The palpi are white, sometimes with dark spots on the sides of the joints.

The front end of the abdomen has a hard piece on the under side from the pedicel to the epigynum, which extends upward on each side, so that the edges are visible from above. The epigynum has a wide oval opening, in the front part of which are two small openings to the tubes.

The males differ but little from the females in color and general appearance. The head is higher and narrower, and the mandibles a little longer, turned obliquely forward and curved apart in the middle. Fig. 5e. The male palpi are large. The tibia is short and has a very large hook. Fig. 5f. The palpal organ is large and only half covered by the tarsus. The tube passes completely around

the bulb, then passes through the usual groove to the outside of the tarsus, where it is coiled once around the flattened end. Fig. 5*e*.

This species lives on plants and matures early in the summer. At first sight it resembles an ant, but its gait is slower and steadier. I have never seen it jump but it runs quickly when frightened. It lives in summer on bushes, and matures in June. In the latter part of summer only young are to be found, and in the winter it hides under leaves on the ground.

Common at New Haven, Conn., and around Boston, Mass.

Salticus ephippiatus, Peckham

Synemosyna ephippiata Hentz

This spider is 7mm long, the cephalothorax 3mm long, and half as wide. In color and general appearance it resembles orange-brown ants. The cephalothorax is high in front and low behind the dorsal groove, which is in a slight depression. Pl. XXI, fig. 4*a*. The sides of the cephalothorax are nearly straight for two-thirds its length, and it is only slightly narrowed behind. The abdomen is oval, a little narrower in front than behind The legs are long and slender, their length 4, 1, 3, 2. Fig. 4.

The colors are various shades of orange-brown, some individuals being very dark, and others pale. There is an indistinct light mark across the middle of the cephalothorax and across the abdomen, a little in front of the middle, and sloping backward down the sides, nearly to the spinnerets.

The femora of all the legs are dark, except a light stripe on the front of those of the first pair. The patella and tibiæ are all light on the upper side and darker beneath. The metatarsi of the hind legs are dark, the others partly light in the middle, or on the upper side. The tarsi of the front legs are dark, the others light. The coxæ of the third legs are dark, the others light. The palpi of the female have the tibia and tarsus very much thickened and covered with stiff hairs on the under side. The palpi are colored as dark as the head. The epigynum has two small openings near together, and turned toward each other. Fig. 4*c*.

Eastern Massachusetts and New Haven, Conn., under leaves, and on plants in summer.

Synageles picata, Peckham.

Synemosyna picata Hentz.

I have one young male from New Haven, Conn., that appears to be of this species. Pl. XXI, fig. 3. It is as large as adults sent me from Wisconsin by Mr. Peckham, but not as distinctly marked. The cephalothorax has the two white spots in the middle, but is not depressed at this part as in the adult. Fig. 3*a*. The coloring is more uniform than in the Wisconsin specimens. The white marks on the abdomen show indistinctly as do the markings of the legs. The specimen is 3.5^{mm} long.

The adults of both sexes have a slight elevation around the posterior eyes, and a distinct depression across the cephalothorax, just behind the eyes. Fig. 3*b*. The front legs of the female are twice as thick as the other legs, fig. 3*c*, and the front legs of the male are still thicker, especially in the femur and tibia. Fig. 3*d*. The patella and tibia are flattened in front, more in the male than in the female. The front of these legs, and the front of the cephalothorax of the male, are purple and iridescent in a bright light. In alcohol they become dark brown. The abdomen has two white stripes extending down the sides in the shallow depression across the front third. The abdomen in front of the depression is rounded, and sometimes swells in alcohol to an unnatural width. The hinder half of the cephalothorax and front of the abdomen are lighter colored than the parts before and behind.

EXPLANATION OF PLATES.

PLATE XVI.

Fig. 1. *Phidippus rufus*, female × 4; 1*a*, male × 4; 1*b*, female, nearly full grown; 1*c*, young; 1*d*, young soon after leaving the cocoon, 1*e*, epigynum; 1*f*, epigynum of another female; 1*g*, immature epigynum; 1*h*, male palpus; 1*i*, male palpus; 1*j*, brown scales from young female; 1*k*, yellow scale from young female.

Fig. 2. *Phidippus brunneus*, epigynum.

Fig. 3. *Phidippus mystaceus*, female × 4; 3*a*, 3*b*, male palpus; 3*c*, epigynum; 3*d*, posterior notch of epigynum of another female.

Fig. 4. *Phidippus ruber* Keys; male × 4; 4*a*, epigynum; 4*b*, male palpus; 4*c*, male palpus.

Fig 5. *Phidippus tripunctatus*, female × 4; 5*a*, end of mandibles of male; 5*b*, male palpus; 5*c*, patella and tibia of male palpus; 5*d*, white scales from middle of abdomen.

PLATE XVII.

Fig. 1. *Dendryphantes militaris*, female × 4; 1*a*, male × 4; 1*b*, mandible of male, under side; 1*c*, mandible of male, upper side; 1*d*, male palpus.

Fig. 2. *Dendryphantes æstivalis*, female of light variety × 4; 2*a*, cephalothorax of same female after wetting with alcohol; 2*b*, female of small dark variety; 2*c*, small male × 8; 2*d*, 2*e*, male palpus; 2*f*, epigynum.

Fig. 3. *Dendryphantes montanus*, cephalothorax of female; 3*a*, cephalothorax of male; 3*b*, mandible of male; 3*c*, epigynum with two forms of posterior notch; 3*d*, 3*e*, male palpi.

Fig. 4. *Zygoballus bettini*, female × 6; 4*a*, mandibles of male under side; 4*b*, male palpus.

Fig. 5. *Zygoballus terrestris*, female × 8; 5*a*, mandible of male; 5*b*, epigynum; 5*c*, male palpus; 5*d*, outer side of tibia of male palpus

PLATE XVIII.

Fig 1. *Icius palmarum*, female × 4; 1*a*, side of cephalothorax of female; 1*b*, front of head of a male with short mandibles; 1*c*, cephalothorax of male with long mandibles; 1*d*, under side of mandibles of male, 1*e*, epigynum, 1*f*, another pattern of dorsal markings of female; 1*g*, male × 4; 1*h*, male palpus; 1*i*, male palpus, showing tibial hook.

Fig. 2. *Icius mitratus*, male × 4.

Fig. 3. *Icius elegans*, female × 4; 3*a*, side of cephalothorax; 3*b*, front of head of female; 3*c*, under side of cephalothorax; 3*d*, male × 4; 3*e*, front of head of male; 3*f*, 3*g*, male palpus, 3*h*, epigynum.

Fig. 4. *Icius elegans*, dark variety of male × 4; 4*a*, front of head, 4*b*, 4*c*, male palpus

Fig 5. *Icius hartii*, female × 4, 5*a*, male from a Wisconsin specimen from Mr Peckham; 5*b*, male palpus, 5*c*, tibial hook; 5*d*, epigynum

Fig. 6. *Icius formicarius*, female × 4; 6*a*, side of cephalothorax; 6*b*, epigynum

PLATE XIX.

Fig 1. *Mævia vittata*, back of female × 4; 1*a*, dark variety of male × 4, 1*b*, light variety of male × 4; 1*c*, male palpus; 1*d*, epigynum.

Fig. 2. *Salticus scenicus*, female × 4; 2*a*, male; 2*b*, side of cephalothorax of female; 2*c*, mandibles of male; 2*d*, male palpus; 2*e*, epigynum; 2*f*, tibial hook from above; 2*g*, tibial hook from side.

Fig. 3. *Marptusa familiaris*, back of female × 4; 3*a*, front of head and mandibles; 3*b*, male palpus; 3*c*, side of male palpus without tarsus; 3*d*, side of cephalothorax of female; 3*e*, 3*f*, epigynum of two individuals

Fig. 4. *Menemerus binus*, female × 4; 4*a*, epigynum.

Fig. 5. *Menemerus lineatus*, female × 4; 5*a*, end of mandible; 5*b*, epigynum.

PLATE XX.

Fig. 1. *Neon nellii*, back of female; 1*a*, side of female; 1*b*, epigynum; 1*c*, male palpus.

Fig 2 *Euophrys monadnock*, side of male, 2*a*, under side of cephalothorax of male, 2*b*, front of head; 2*c*, top of cephalothorax of male, 2*d*, 2*e*, male palpus, 2*f*, female, 2*g*, epigynum

Fig 3 *Attus palustris*, female × 4, legs in a natural position, 3*a*, male palpus, 3*b*, tibial hook from outside, 3*c*, epigynum

Fig 4 *Attus sylvestris*, male × 4

Fig 5 *Habrocestum splendens*, male × 6, 5*a*, front of head, 5*b*, side of cephalothorax, 5*c*, male palpus, 5*d*, tibial hook

Fig 6 *Habrocestrum peregrinum* female × 4, 6*a*, epigynum, 6*b*, patella and tibia of third leg of male, front side

Fig 7 *Saitis pulex*, male × 4, 7*a*, female × 4, 7*b*, cephalothorax of male, side view, 7*c* male palpus, 7*d* 7*e*, tibial hook, 7*f*, face of male, 7*g* epigynum

Fig 8 *Euophrys cruciata*, male × 4, 8*a*, front of head, 8*b*, male palpus from below 8*c* male palpus from side with tibial hook, 8*d*, end of the tarsus of male palpus, 8*e*, side of cephalothorax

Plate XXI

Fig 1 *Phlegra leopardus* female × 4, 1*a*, under side of cephalothorax 1*b*, epigynum, 1*c* male palpus from above, 1*d*, male palpus, under side, 1*e* tibial hook, outer side

Fig 2 *Hasarius hoyi*, young female × 4 2*a*, same individual after keeping in alcohol 2*b* 2*c* abdominal markings of adult females, 2*d*, dorsal markings of young female 2*e*, epigynum, 2*f*, 2*g*, male palpus

Fig 3 *Synageles picata* young female × 6, 3*a*, side of young female 3*b*, side of cephalothorax of adult female from Wisconsin 3*c*, first and second legs of female × 12, 3*d* first and second legs of male × 12, from Wisconsin specimens

Fig 4 *Salticus ephippiatus*, female × 6, 4*a*, side of cephalothorax of female, 4*b*, palpus of female, 4*c* epigynum

Fig 5 *Synemosyna formica* female × 6, 5*a*, side of female, 5*b*, under side of mouth parts of male, 5*c*, front of head of male, 5*d*, under side of front of abdomen of male, 5*e*, palpus of male, 5*f*, tibial hook, 5*g*, epigynum

XV.—A Provisional List of the Hepaticæ of the Hawaiian Islands. By A. W. Evans.

During the years 1875 and 1876, Mr. D. D. Baldwin made a systematic collection of the Hepaticæ found growing in the Hawaiian Islands, particularly in the island of Maui. These were sent to Prof. Eaton for determination, and he, in turn, sent many of them to Mr. Austin, who published descriptions of several new species and returned to Prof. Eaton a list of his determinations, including many species previously described. The following list is based largely upon those determinations, but contains in addition several of Mr. Baldwin's species which Mr. Austin did not examine. All other species accredited to the Islands in the Synopsis Hepaticarum and in other publications are also mentioned in the list.

Frullania arietina Tayl. Syn Hep. p. 413. Oahu (Mann and Brigham).

F. squarrosa Nees, Syn Hep. p. 416. Oahu (Mann and Brigham); Hawaiian Islands (Hillebrand).

F. Sandvicensis Ångstr. Öfver. af. Kongl. Vet.-Akad Forhandl. 1872, No. 4, p. 28. Hawaiian Islands (Andersson).

F. hypoleuca Nees, Syn. Hep. p. 443. Oahu (Meyen); West Maui (Baldwin, 81!)

F. Kunzei Lehm. et Lindenb. Syn. Hep. p. 449. Oahu (Mann and Brigham), West Maui (Baldwin, 191!).

F. apiculata Nees, Syn. Hep. p 452. Oahu (Mann and Brigham); West Maui (Baldwin, 57! 165!).

F. explicata Mont. Syn. Hep p. 452. Hawaiian Islands (Gaudichaud)

Jubula piligera (*Frullania Hutchinsiæ* Nees, var. β, Syn. Hep p. 426, *F. piligera* Aust. Bull. Torr. Bot. Club, vi, p. 301). Hawaiian Islands (Baldwin, 147!)

Lejeunea alcina Ångstr. Öfver. af. Kongl. Vet.-Akad. Förhandl., 1872, No 4, p. 23. Hawaiian Islands (Andersson).

L. Sandvicensis (*Phragmicoma Sandvicensis* Gottsche, Annal. des Sc Nat 4me série, T. viii, p. 344; *P. subsquarrosa* Aust. Proc. Acad. Nat. Sci Phil, Dec. 1869). Hawaiian Islands (Gaudichaud, Andersson, Hillebrand), West Maui (Baldwin, 113!).

L. elongata Aust. (*Phragmicoma elongata* Aust. Proc. Acad. Nat. Sci Phil, Dec. 1869). Hawliian Islands (Hillebrand, etc.); Kauai (Baldwin, 273!)

L. Mannii Aust Bull. Torr. Bot. Club, v, p. 15. Oahu (Mann and Brigham!).

L. gibbosa Ångstr. l. c. p. 23. Hawaiian Islands (Andersson).

L. Anderssonii Ångstr. l. c. p. 24. Hawaiian Islands (Andersson)

L. ungulata Ångstr. l. c p. 25. Hawaiian Islands (Andersson).

L. Owaihiensis Gottsche, Syn. Hep. p. 351. Hawaii (Herb. Hook.)

L. oculata Gottsche, Syn Hep. p. 357. Hawaii (Herb Hook.).

L. stenoschiza Ångstr. l. c p. 26 Hawaiian Islands (Andersson).

L. Pacifica Mont. Syn Hep. p. 378. Hawaiian Islands (Gaudichaud, Andersson),

L. subligulata (*L. cancellata* Lindenb in Herb. non Nees et Mont ; *L. Sandvicensis* Steph. Hedwigia, xxix, p 88). Hawaiian Islands (Gaudichaud)

L. albicans Nees, Syn. Hep. p. 386 (*L. cucullata* Lindenb. in Herb. non Nees; vid. Steph. l. c. p. 89). Oahu (Meyen).

L. cucullata Nees, Syn. Hep p 390. Hawaiian Islands (Andersson, Hillebrand)

L. calyptrifolia Dum ? (*L calyptrata* Ångstr. l. c. p. 27) Hawaiian Islands (Andersson).

L. Hillebrandii Aust. Bot. Gazette, i, p. 35. Hawaiian Islands (Hillebrand).

L. ceratocarpa Ångstr. l c p. 27 (? *L obcordata* Aust Bot. Gazette, i. p 36). Hawaiian Islands (Andersson); West Mauii (Baldwin).

Radula reflexa Nees et Mont. Syn. Hep. p 253. Hawaiian Islands (Gaudichaud)

R. Xalapensis Mont. Syn. Hep. p. 255. Hawaiian Islands (Baldwin, 232!).

R. Javanica Gottsche, Syn. Hep p 257 Hawaii (Herb Hook.); East Maui (Baldwin, 50, 179!).

R. Mannii Aust Bull. Torr Bot. Club, v, p. 15. Oahu (Mann and Brigham!); East Maui (Baldwin, 21!)

Porella Hawaiiensis n. sp West Maui (Baldwin!).

Brownish-green, cæspitose; stems one- to three-pinnate; leaves loosely imbricated, spreading, falcate-ovate, the margins mostly entire or toothed towards the apex, which is coarsely and irregularly spinulose-dentate, the ventral margin distinctly folded at about the middle; lobule narrow, lingulate-ovate, with entire or undulate margins; amphigastria about the width of the stem, ovate, mostly entire, the apex variously one- to four-toothed; fruit not seen.

Leaves about $1{\cdot}5^{mm}$ long, $0{\cdot}5^{mm}$ wide; cells in middle of leaf $0{\cdot}025^{mm}$ in diameter.

Allied to *Madotheca ligulifera* Tayl. (Syn. Hep. p. 263, n. 1), from which it differs in the shape of the leaves, in their mode of insertion, and, especially, in the peculiar characters of the amphigastria.

P. lævigata Lindb. (*Madotheca lævigata* Dum Syn. Hep. p. 276). East Maui (Baldwin, 222!).

Pleurozia gigantea Lindb (*Physiotium sphagnoides* Nees, Syn. Hep. p. 235). Hawaii (Herb. Hook.).

Var. major (Jack), Hedwigia, xxv, p. 65. Hawaii (Herb. Carrington).

P. cochleariformis Dum (*Physiotium cochleariforme* Nees, Syn. Hep. p. 235) Hawaii (Herb. Hook.).

P. conchæfolia Aust. (*Physiotium conchæfolium* Syn. Hep. p. 235) Hawaiian Islands (Beechey, etc); West Maui (Baldwin, 18!).

P. subinflata Aust. (*Physiotium subinflatum* Aust. Proc Acad. Nat Sci. Phil, Dec. 1869). Hawaii (Mann and Brigham); West Maui (Baldwin, 47!)

Trichocolea gracillima Aust. Bot. Gazette, iii, p. 6, West Maui (Baldwin, 134!).

Herberta sanguinea Aust. Bull. Torr. Bot. Club, vi, p. 302 (*Sendtnera juniperina*, var. *sanguinea* Mont. Syn. Hep. p. 239). East and West Maui (Baldwin, 15! 92! 98!).

Mastigophora gracilis Mont. (*Sendtnera gracilis*, Syn. Hep. p. 243; *S. tristicha* Aust. Proc Acad. Nat. Sci. Phil, Dec. 1869). Oahu (Mann and Brigham! Baldwin, 274!).

Bazzania? integrifolia (*Mastigobryum? integrifolium* Aust Bot. Gazette, i, p. 32). Hawaiian Islands (Baldwin).

B. patens (*M. patens* Lindenb. Syn. Hep. p. 221; *M. parvistipulum* Aust. Bull. Torr. Bot. Club, v, p. 16). Oahu (Mann and Brigham); West Maui (Baldwin, 68!).

B. Brighami (*M. Brighami* Aust. l. c.). Oahu (Mann and Brigham); Hawaiian Islands (Baldwin!).

B. cordistipula (*M. cordistipulum* Lindenb. Syn. Hep. p. 224) Hawaiian Islands (Gaudichaud, etc.): Oahu (Mann and Brigham); Molokai (Baldwin, 222!)

B. falcata (*M. falcatum* Lindenb. Syn. Hep. p. 231) West Maui (Baldwin, 12!).

B. Baldwinii Aust. Ms. West Maui (Baldwin, 199!).

Stems simple or slightly branched, flagelliferous, clustered; leaves approximate or slightly imbricated, usually somewhat deflexed, triangular-ovate, entire, the apex rounded or variously 1–4-toothed, the dorsal margin arching over the stem, the ventral oblique or somewhat cordate at its insertion; amphigastria a little wider than the stem, orbicular-quadrate, entire or crenulate above.

Stems 3–4^{cm} long; leaves 0·7–0·8^{mm} long by 0·4–0·6^{mm} wide; leaf-cells averaging about 0·024^{mm} in diameter.

B. deflexa Underw. (*M. deflexum* Nees, Syn. Hep. p. 231). East Maui (Baldwin, 231!).

B. minuta (*M. minutum* Aust. Bull. Torr. Bot. Club, v, p. 17). Hawaiian Islands (Hillebrand); East Maui (Baldwin, 65 in part!).

Lepidozia Sandvicensis Lindenb. Syn. Hep. p. 201 (*L. filipendula* Tayl. Syn. Hep. p. 713). Hawaiian Islands (Tolmie, etc.); West Maui (Baldwin, 69!).

L. reptans Nees. West Maui (Baldwin, 150!).

Cephalozia multiflora Spruce. Oahu (Mann and Brigham).

C. Sandvicensis (*Jungermannia Sandvicensis* Mont Syn. Hep. p. 142). Hawaiian Islands (Gaudichaud).

Odontoschisma subjulacea Aust Bull. Torr. Bot. Club, vi, p. 303 (*J. caudifera* Tayl Mss, in part). West Maui (Baldwin, 233!).

O. Sandvicensis (*Sphagnœcetis Sandvicensis* Ångstr. Öfver. af Kongl. Vet.-Akad. Forhandl., 1872, No 4, p. 22). Hawaiian Islands (Andersson).

Kantia bifurca (*Calypogeia bifurca* Aust. Proc. Acad. Nat. Sci. Phil., Dec. 1869). Hawaiian Islands (Hillebrand).

K. bidentula (*C bidentula* Nees, Syn Hep p 199). West Maui (Baldwin, 101!).

K. Baldwinii (*C. Baldwinii* Aust Bot. Gazette i, p. 32). West Maui (Baldwin, 141!).

Saccogyna? Bolanderi (*Gymnanthe? Bolanderi* Aust., Proc. Acad. Nat. Sci. Phil., Dec. 1869). Hawaiian Islands (Hillebrand).

Scapania undulata Dum. var. West Maui (Baldwin, 94 in part!).

S. Oakesii Aust.? West Maui, young specimens (Baldwin, 94 in part!).

S. nemorosa Dum. East and West Maui, a small form (Baldwin, 149, 214!).

S. planifolia Dum. West Maui (Baldwin, 83!).

Diplophyllum albicans Dum (*Jungermannia albicans* Linn. Syn. Hep. p. 75). East Maui (Baldwin, 245!).

Lophocolea connata, var β? Syn. Hep. p 153. West Maui (Baldwin, 66!). The specimens are all sterile and may possibly be *L. Martiana* Nees.

L. Breutelii Gottsche, Syn. Hep. p. 154. West Maui, mixed with the preceding species!

L. Columbica Gottsche, Syn Hep. p. 155. West Maui (Baldwin, 91, in part).

L. Orbigniana Mont. et Nees, Syn. Hep. p 156. West Maui (Baldwin, 76!).

L. Gaudichaudii Mont Syn. Hep. p. 156. Hawaiian Islands (Gaudichaud); West Maui (Baldwin, 111!).

L. bidentata Dum. Syn Hep. p. 159 West Maui (Baldwin, 140!).

L. Beecheyana Tayl. Syn. Hep p. 690. Oahu (Beechey in Herb. Hook).

L. spinosa Gottsche, Syn Hep. p 170 Hawaii (Herb. Hook.).

Plagiochila simplex Lindenb. Syn. Hep p 30. East and West Maui (Baldwin, 117! 184! 196! 205! 237!)

P. gracillima Aust. Ms. Molokai (Baldwin, 211!).

Much branched, glossy, and bearing numerous flagellæ; leaves of stem and main branches distant, oblong-ovate, the dorsal margin curved, usually entire, slightly decurrent at base, the ventral either entire or bearing 1 or 2 sharp teeth, the apex strongly emarginate-

bidentate with sub-equal divergent teeth ; leaves of flagellæ minute, mostly bidentate.

Leaves 0.8^{mm} long, 0·45^{mm} wide ; cells of leaves averaging 0·018^{mm} in diameter.

P. frondescens Nees, Syn. Hep p. 31. East Maui (Baldwin, 5, 85 !).

P. Gaudichaudii Mont. et Gottsche, Annal des Sc. Nat 4me série, T. vi, p. 193 (*P. tenuis* Mont. non Lindenb). Hawaiian Islands (Gaudichaud, Andersson)

P. Baldwinii Aust. Ms. (*P. flava* Aust. Ms). West Maui (Baldwin, 115 !).

Loosely cæspitose, brownish-yellow, robust ; stems simple or sparingly branched ; leaves sub-imbricated, ovate, slightly curved, the margins entire or a little undulate, the dorsal decurrent ; the apex rounded, usually bearing from one to three sharp teeth.

Stem 5–8^{cm} long ; leaves 2–2·5^{mm} long, 1^{mm} wide ; cells 0·027^{mm} in diameter.

P. fissidentoides Tayl. Syn. Hep. p 636. Hawaiian Islands (Menzies); West Maui (Baldwin, 95).

P. adiantoides Lindenb. Syn Hep p 38. Oahu (Mann and Brigham)

P. deflexa Mont et Gottsche, Annal des Sc Nat. 4me série, T vi, p. 192 (*P. patula* Mont. non Nees et Mont , *P patens* Aust. Ms) Hawaiian Islands (Gaudichaud); West Maui (Baldwin, 60 !)

P. Owaihiensis Nees et Lindenb Syn Hep. p 46. Hawaii (Herb Hook); Oahu, West Maui, Kauai (Baldwin, 160 ! 201 ! 206 !).

P. Eatoni Aust. Ms. West Maui (Baldwin, 109 !)

Stems mostly simple ; leaves opposite, loosely imbricated, spreading, slightly unsymmetrical (the leaves on one side being more obliquely inserted than on the other), orbicular-ovate, entire, the dorsal margins decurrent, the ventral connate at insertion.

Stems 10–12^{cm} long ; leaves 1·5–2^{mm} long, 1–1·5^{mm} wide. *P. Eatoni* is apparently a near ally of *P. Brauniana* Nees (Syn. Hep. p. 51, n. 70) but the leaves are distinctly imbricated and somewhat longer than they are broad.

P. oppositifolia Aust. Bull. Torr. Bot Club, v, p. 16 Hawaiian Islands (Hillebrand); West Maui (Baldwin, 93 ! 97 !).

P. biserialis Lehm. et Lindenb. Syn. Hep. p. 53. East Maui (Baldwin, 216 !)

P. deltoidea Lindenb. Syn Hep. p 55. West Maui (Baldwin, 198 !).

P. acutiuscula Aust. Ms. West Maui (Baldwin, 116 !).

Pale brownish-green, cæspitose, glossy ; stems simple ; leaves imbricated, spreading, ovate, the margins entire except at the apex,

which is sharply incised-dentate, the apical tooth being larger than the others and projecting beyond them.

Stems 2·5–4^{cm} long; leaves 1^{mm} wide, 1·5–2^{mm} long; leaf-cells averaging 0·033^{mm} in diameter.

Several other possibly distinct *Plagiochilæ* occur in too small quantity for determination.

Mylia Taylori S F Gray (*Jungermannia Taylori* Hook. Syn Hep p 82). Hawaii (Herb Lehm)

Jungermannia piligera Nees, Syn Hep p 81 Oahu (Meyen), West Maui (Baldwin, 79 !)

J. rigida Aust Proc Acad. Nat Sci Phil, Dec. 1869. Hawaiian Islands (Hillebrand), West Maui (Baldwin, 64 ! 154 !).

J. robusta Aust l c Hawaiian Islands (Hillebrand), West Maui (Baldwin, 268 !)

J. coriacea Aust. l c Hawaiian Islands (Hillebrand, Baldwin !)

J. macrophylla Ångstr Ofver af Kongl Vet-Akad. Forhandl 1872, No 4, p 22 Hawaiian Islands (Andersson)

J. subulata n sp Hawaiian Islands (Baldwin !).

Cæspitose, brownish-green; stems mostly simple, creeping, ascending at the apex, radiculose; leaves spreading, imbricated, ovate, entire, rounded at the apex; amphigastria wanting; outer involucral leaves like the stem-leaves, the inner very small, awl-shaped, slightly denticulate; perianth (young), oblong-obovate, contracted at the denticulate mouth, surpassing the inner involucral leaves, scarcely, if at all, plicate.

Leaves 2–2·5^{mm} long, 1–1·5^{mm} wide; cells oval, about 0·029^{mm} in width, those of the inner involucral leaves rapidly increasing in size at the apex and resembling in character the terminal cells of the perianth.

J. lurida Dum. (*J. nana* Nees, Syn Hep. p 91) Hawaiian Islands (Hillebrand).

J. Esenbeckii Mont. Syn. Hep. p. 98 Hawaiian Islands (Gaudichaud, Andersson).

J. lucens n. sp. East Maui (Baldwin, 65, in part !).

Loosely tufted, whitish-green; stems simple or innovating from beneath the involucre, rootless; leaves remote, except at the summit of the stem where they are imbricated, loosely areolate, pellucid, sub-transverse, entire, complicate, bilobed about one-third their length, the lobes acute and nearly equal with an acute sinus; involucral leaves about three, deeply two-lobed, the margins irregularly

sinuous-denticulate; perianth ovate-cylindrical, somewhat plicate at the dentate mouth.

Stems 1·5–2·5^{cm} long; leaves 0·5–0·75^{mm} long, 0·4–0·7^{mm} wide; leaf-cells averaging 0·055^{mm} long by 0·035^{mm} wide.

This species is allied to *J. minuta* Crantz; it differs in its larger size, in the larger and looser areolation of its leaves, in its pale color, and in its normally two-cleft involucral leaves. The sinus of the leaves has an angle of a little less than 90°; the sinus of the involucral leaves is often much sharper.

Nardia callithrix Spruce (*J callithrix* Lindenb et Gottsche, Syn Hep p 673) Hawaiian Islands (Hillebrand)

N. Mauii (*J. Mauii* Aust Bull Torr Bot Club, vi, p 303) West Maui (Baldwin, 242!)

N. exserta n sp West Maui (Baldwin, 264!).

Diœcious, cæspitose, dark or blackish green; stems simple, radiculose, rigid, erect; leaves subtransversely inserted, imbricated, obliquely spreading, orbiculate, entire; amphigastria none; involucral leaves two or three, similar to the stem-leaves, slightly connate with the perianth at its base; perianth large, long-exserted, obovoid or campanulate, slightly plicate, the mouth open, lacerate.

Stems 2–3^{cm} long; leaves about 1^{mm} in diameter, the cells averaging 0·025^{mm} in diameter; perianth about 3^{mm} in length.

Tylimanthus integrifolius n sp. East and West Maui (Baldwin, 95! 183!).

Diœcious, cæspitose, brownish-green; stems simple or somewhat pinnately divided, eradiculose except near the extremity of fruiting stems; leaves contiguous or slightly imbricated, oblong or ovate, the margins mostly entire, except near the involucre where they are irregularly crenulate, the dorsal margin often more or less indented near the rounded apex; amphigastria none; involucre ovoid, thickened, with numerous radicles.

Stems about 4^{cm} long; leaves 1–1·5^{mm} long, 1^{mm} wide; cells 0·025^{mm} in diam. in middle of leaf, longer towards base; involucre 2·5–3^{mm} long, 1^{mm} wide.

Pallavicinia cylindrica (*Steetzia cylindrica* Aust Bull. Torr Bot Club, v, p. 17). Hawaiian Islands (Hillebrand); West Maui (Baldwin, 70 in part!).

P. Baldwinii (*S. Baldwinii* Aust. l. c. vi, p. 303) West Maui (Baldwin, 70 in part).

Symphyogyna semi-involucrata Aust. l. c. v, p. 15. Oahu (Mann and Brigham); Hawaiian Islands (Baldwin!).

Metzgeria dichotoma Nees. Syn. Hep. p. 504. West Maui (Baldwin, 106!).

Aneura multifida Dum. Syn. Hep. p. 496. Oahu (Mann and Brigham); Hawaiian Islands (Hillebrand).

A. pinnatifida Nees, Syn. Hep. p. 495. West Maui (Baldwin, 110!).

A. palmata Dum. Syn. Hep. p. 498. Oahu (Mann and Brigham); Hawaiian Islands (Hillebrand).

A. pectinata Aust. Bull. Torr. Bot. Club, v, p. 15. Oahu (Mann and Brigham); Hawaiian Islands (Hillebrand); West Maui (Baldwin, 71!).

A. pinguis Dum. Syn. Hep. p. 493. West Maui (Baldwin, 119!).

Dendroceros Clintoni Aust. Bull. Torr. Bot. Club, v, p. 14. Hawaiian Islands (Mann and Brigham).

Anthoceros Vincentianus Lehm. et Lindenb. Syn. Hep. p. 587. Kauai (Baldwin, 238!).

A. vesiculosus Aust. Bull. Torr. Bot. Club, v, p. 17. Hawaiian Islands (Hillebrand, Baldwin!).

Marchantia polymorpha Linn. Syn. Hep. p. 522. Hawaiian Islands (Hillebrand).

M. crenata Aust. Bull. Torr. Bot. Club, v, p. 14. Hilo (Mann and Brigham!).

M. disjuncta Sull. Mem. Amer. Acad. n. ser. iii, p. 63. Hawaiian Islands (Baldwin, 90! 145 in part!).

The male receptacles agree with Sullivant's description and figures, but the female are not so deeply parted as he represents.

Several other species of *Marchantia*, which were considered new and named provisionally by Austin, occur in too small quantity for description.

Fimbriaria innovans Aust. (*Marchantia innovans* Aust. Bull. Torr. Bot. Club, v, p. 14). Hanalei, Kauai (Mann and Brigham); East Maui (Baldwin, 89!).

Dumortiera hirsuta Nees, Syn. Hep. p. 543. Hawaiian Islands (Hillebrand); Maui (Mann and Brigham, Baldwin!).

D. trichocephala Nees, Syn. Hep. p. 545. Hawaiian Islands (Douglas); Oahu (Mann and Brigham).

D. Nepalensis Nees. Hawaiian Islands (Hillebrand).

Aitonia cordata (*Plagiochasma cordata* Lehm. et Lindenb. Syn. Hep. p. 512). Hawaiian Islands (Hillebrand).

DESCRIPTION OF FIGURES.

PLATE XXII.

Porella Hawaiiensis, n. sp Fig. 1 Plant × ½; fig. 2, branch, ventral view × 12; fig. 3, pair of leaves, dorsal view × 12.

Bazzania Baldwinii Aust. Ms. Figs. 4, 5. Parts of stems, dorsal and ventral views × 12.

Plagiochila gracillima Aust. Ms. Figs 6, 7. Parts of stems, dorsal and ventral views × 12.

P. Baldwinii Aust. Ms. Fig. 8. Stem × ½: figs 9, 10, parts of stems, dorsal and ventral views × 6.

P. Eatoni Aust. Ms Figs. 11, 12 Parts of stems, dorsal and ventral views × 6.

P. oppositifolia Aust Fig. 13. Plant × ½; figs 14, 15, parts of stems, dorsal and ventral views × 6; fig. 16, involucral leaf × 6, fig 17, perianth × 6.

PLATE XXIII.

Plagiochila acutiuscula Aust. Ms. Figs. 1, 2. Parts of stems, dorsal and ventral views × 6.

Jungermannia subulata, n. sp Fig. 3. Extremity of fruiting stem with perianth × 6, fig. 4, involucral leaf × 75

J. lucens, n. sp. Fig. 5. Fertile stem × ½; fig 6, extremity of same × 6; fig 7, extremity of sterile stem × 6; fig 8, leaf expanded × 6; fig. 9, involucral leaves × 6; fig. 10, perianth × 6.

Nardia exserta, n. sp Fig 11. Extremity of fertile stem, showing perianth × 6.

Tylimanthus integrifolius, n. sp. Fig. 12. Extremity of fertile plant, showing involucre × 6; figs. 13, 14, parts of sterile stems, dorsal and ventral views × 6

XVI.—An Arrangement of the Genera of Hepaticæ. By A. W. Evans.

At the beginning of the present century, the writers on Hepaticæ included nearly the whole of the present order Jungermanniaceæ under the single genus *Jungermannia*. The only exception to this rule was in the case of *Blasia pusilla*, which was usually kept as a distinct genus; but even this was reduced to a species of *Jungermannia* by Hooker in his "British Jungermannieæ" finished in 1816. The splitting-up of this vast genus *Jungermannia* was begun by Raddi (1820), who, in an account of some of the Italian Hepaticæ, arranged his species under a dozen or more distinct genera. He was quickly followed in this work of division by S. F. Gray (1821) and by Dumortier (1822). Each of these three investigators worked independently, and, in this way, gave rise to a mass of synonymy which has since caused a great deal of confusion. The work of Gray, which remained overlooked by botanists for more than forty years, has been especially unfortunate in this respect; and this chiefly on account of the generic names which he employed. In nearly every case, these were derived from the names of persons, but, instead of using the feminine termination, as is usual in such cases, Gray wrote his names in the masculine, and published such genera as Bazzanius, Kantius, etc. Most recent writers have, nevertheless, adopted these names in an emended form, the termination being changed into the feminine.

In the Synopsis Hepaticarum (1844–47), most of the genera of Raddi and Dumortier were acknowledged; but, in some cases, the names adopted for these genera were the later ones of Corda (1829) and of Nees von Esenbeck (1833–38), so that they ought no longer to be retained. Since the publication of this volume, there has been no very comprehensive work on descriptive hepaticology. The numerous shorter works on the species of limited regions or of special groups, which have appeared from time to time, have, however, contained a number of new genera; and, since many of these papers appeared in local periodicals or in the transactions of scientific societies, they are now difficult of access.

Taking these facts into consideration, it has been thought well to bring together, in an arrangement, the various genera which are

acknowledged by most recent hepaticologists. Under each genus, the place and the date of its original publication have been given, together with enough of the synonymy to show the claims of the accepted name for recognition. The names of Gray are in all cases given with the feminine termination.

The arrangement adopted is based on that of Dr. Underwood in the Sixth Edition of Gray's Manual. It combines peculiarities of both Lindberg's and Spruce's arrangements. The tribal names are mostly taken from Lindberg.

In the preparation of this and the preceding paper, my sincere thanks are due Prof. D. C. Eaton, who has allowed me the use of his library and herbarium, and who has given me much bibliographical and critical assistance.

ORDER I. JUNGERMANNIACEÆ.

TRIBE I. FRULLANIEÆ.

1. **Frullania** Raddi, Jung. Etr. in Mem. Moden. xviii, p. 30 (1820): Dum Rev. des Genres, p. 12: Hep. Eur p. 26: G. L. & N. Syn. Hep p. 408: Spruce, Hep. Amaz. et And. in Trans Bot. Soc Edin. xv, p. 3.

Jubula Dum. Comm. bot. p. 112 (1822), in part.

Jubula, sect **Ascolobia** Dum. Syll. Jung. p 36.

Widely distributed; species about 150. The genus is divided by Spruce (Hep. Amaz. et And.) into six subgenera:—*Chonanthelia, Trachycolea, Homotropantha, Meteoriopsis, Thyopsiella* and *Diastaloba.*

2. **Jubula** Dum. Comm. bot. p 112 (1822), in part.

Jubula, sect. **Jubulotypus** Dum. Syll. Jung. p. 36.

Jubula Dum. Rev. des Genres, p. 12 (1835); Hep. Eur. p 26: Spruce. Hep. Amaz. et And. p. 59. Underwood in Gray's Manual, Ed. vi, p. 708.

Frullaniæ sp. G. L. & N. Syn. Hep p. 426.

Consists of 2 species,—the variable *J. Hutchinsiæ* Dum. of Europe and America and *J. piligera* (Aust.) of the Pacific, which is perhaps a variety of the first.

3. **Lejeunea** Lib. in Ann gen. sc. phys. T. 5, p. 372 (1820): Dum. Comm. bot. p. 111; Syll. Jung. p. 32; Rev. des Genres, p. 11; Hep. Eur. p. 18: G. L. & N. Syn. Hep. p. 308.

As now defined by most hepaticologists, the genus includes—

Marchesinia S. F. Gray, Nat. Arr. Br. Pl. i, p. 689 (1821), (**Phragmicoma** Dum. Comm. bot p. 112; Syll. Jung. p. 35; Rev. des Genres, p. 13; Hep. Eur. p. 30: G. L. & N. Syn. Hep. p. 292);

Colura Dum. Rev. des. Genres, p. 12;

Omphalanthus Lindenb. & Nees in Syn. Hep. p. 303;

Ptychanthus Nees, Hep. Eur. iii, p. 105: G. L. & N. Syn. Hep. p. 289;
Thysananthus Lindenb. in Syn. Hep. p. 286;
Bryopteris Lindenb. l. c. p. 284.

The genus *Lejeunea* is very widely distributed but is especially abundant in tropical regions. As first published by Mademoiselle Libert, it contained 2 species,—*L. calcarea* and *L. serpyllifolia* of Europe and America; in its present extended sense it is the largest genus of Hepaticæ, and contains 300 to 400 species. The genus is divided by Spruce (Hep. Amaz. et And.) into 2 sections and 38 subgenera, as follows:—§ 1. **Holostipæ**, comprising the subgenera *Stictolejeunea*, *Neurolejeunea*, *Peltolejeunea*, *Omphalolejeunea*, *Archilejeunea*, *Ptycholejunea*, *Mastigolejeunea*, *Thysanolejeunea*, *Dendrolejeunea*, *Bryolejeunea*, *Acrolejeunea*, *Lopholejeunea*, *Platylejeunea*, *Anoplolejeunea*, *Brachiolejeunea*, *Homalolejeunea*, *Dicranolejeunea* and *Odontolejeunea*. § 2. **Schizostipæ**, comprising the subgenera *Prionolejeunea*, *Crossotolejeunea*, *Harpalejeunea*, *Trachylejeunea*, *Drepanolejeunea*, *Leptolejeunea*, *Ceratolejeunea*, *Taxilejeunea*, *Macrolejeunea*, *Otigoniolejeunea*, *Hygrolejeunea*, *Euosmolejeunea*, *Pycnolejeunea*, *Potamolejeunea*, *Cheilolejeunea*, *Eulejeunea*, *Microlejeunea*, *Cololejeunea*, *Diplasiolejeunea* and *Colurolejeunea*.

4. **Myriocolea** Spruce, Hep. Amaz. et And. p. 305 (1884).

Contains a single species, *M. irrorata* Spruce of South America.

5. **Radula** Dum. Comm. bot. p. 112 (1822), in part.

Radula, sect **Radulotypus** Dum. Syll. Jung. p. 38 (1831).

Radula Dum. Rev. des Genres, p. 14 (1835); Hep. Eur p 31 (1874): G. L. & N. Syn. Hep. p. 253.

Candollea Raddi, Jung. Etr. in Mem. Moden. xviii, p 24 (1820), in part, not **Candollea** Labil.

Martinellia S. F. Gray, Nat Arr. Br. Pl. i, p. 690 (1821), in part.

A widely diffused genus of about 75 species, the typical one being the common *R. complanata* Dum. The genera *Radula* and *Martinellia*, as first proposed by their authors, included the genera *Radula*, *Scapania* and *Plagiochila*, as these are now understood. In his Sylloge (pp. 37–43), Dumortier divided his original *Radula* into three sections:—*Radulotypus*, *Scapania* and *Plagiochila*; these he soon elevated into the genera *Radula*, *Scapania* and *Plagiochila* with almost their present limitations (Rev. des Genres, p. 14). If we supersede any of Dumortier's names by the older *Martinellia* of Gray, it should be *Radula*, since the first of Gray's species of *Martinellia* belong to that genus. As, however, Gray's genus is so loosely defined, and Dumortier's names are in so universal use, it is

best to retain the latter, in accordance with the views of most authors. (See Carrington, Brit. Hep. p. 52.)

6. **Porella** Dill. Hist. Musc. p. 459 (1741): Lindb. in Act Soc. Sc. Fenn. ix, pp. 329–345 (1869).

Madotheca Dum. Comm. bot. p 111 (1822); Syll. Jung. p. 30; Rev. des Genres, p. 11: G. L & N. Syn. Hep. p. 262.

Cavendishia S. F. Gray, Nat. Arr. Br. Pl. i, p. 689, not **Cavendishia** Lindl

Bellincinia and **Antoiria** Raddi, Jung. Etr. in Mem. Moden. xviii. pp. 18, 19.

A widely distributed genus of 75–100 species. The original species is *P. porella* of Linnæus, which both he and Dillenius placed among the Musci; here it remained overlooked, until it was brought to light by Lindberg.

7. **Pleurozia** Dum. Rev. des Genres, p. 15 (1835); Hep. Eur. p. 52.

Radulæ sp. Dum Syll Jung. p. 38.

Physiotium Nees, Eur. Leberm. iii, p. 75 (1838): G. L. & N. Syn. Hep p 234: Jack, Hedwigia, xxv, p. 49.

Jack enumerates 10 species in his monograph of the genus; of these one only, *P. cochleariformis*, occurs in Europe, the others being confined to Asia and the Pacific Islands.

TRIBE II. PTILIDIEÆ.

8. **Ptilidium** Nees, Eur Leberm. i, p. 95 (1833): G. L. & N. Syn. Hep. p. 249.

Jungermannia, sect **Blepharozia** Dum. Syll. Jung. p. 16 (1831).

Blepharozia Dum. Rev. des Genres, p. 16 (1835).

A genus of about 8 species, the typical *P. ciliare* Nees being widely distributed.

9. **Trichocolea** Dum. Comm. bot p 113 (1822); Syll. Jung. p. 66; Rev. des Genres, p. 20; Hep. Eur p. 111: G. L & N. Syn. Hep. p. 236

A small but widely distributed genus of which the type is *T. tomentella* Dum.

The name of the genus was first published by Dumortier in his Commentationes as "*Thricolea*," which spelling he retained in his Sylloge. Nees von Esenbeck corrected the spelling to "*Trichocolea*" (Eur. Leberm. iii, p. 105); but Dumortier, objecting to the sound of this name, shortened it into "*Tricholea*" both in his Revision des Genres and in his Hepaticæ Europæ. As, however, the name "*Trichocolea*" is preserved by most authors, it has been retained here.

10. **Leiomitra** Lindb. in Act. Soc. Sc. Fenn. x, 515 (1875).

Lindberg gives 2 species,—*L. tomentosa* of tropical America and *L. capillata* of the Philippine Islands; several additional species are described by Spruce.

11. **Chætocolea** Spruce, Hep Amaz et And p 346 (1885)

Contains a single South American species.

12. **Lepidolæna** Dum Rev des Genres, p 13 (1835) Spruce, Hep Amaz et And p. 336

Polyotus Gottsche in G L & N Syn Hep p 13 (1845)

A beautiful genus of the Southern Hemisphere; species 10–15, among which may be mentioned *L. Menziesii*, *L. clavigera* and *L. palpebrifolia*, the original species.

13. **Herberta** S F Gray, Nat Arr Br Pl i, p 705 (1821) Spruce, Hep Amaz et And p 340 Underw in Gray's Manual Ed vi p 709

Schisma Dum Comm bot p 114 (1822) Syll Jung p 76, Rev des Genres, p 23, Hep Eur p 123

Sendtnera Nees in G L & N Syn Hep p 238 (1845).

Widely distributed; species 10–15; the genus is represented in both Europe and America by *H. adunca* Gray.

14. **Lepicolea** Dum Rev des Genres p 20 (1835) Lindb in Act. Soc. Sc Fenn x p 516

Leperoma Mitt in Hook f Handb N Z Fl pp 751, 754 (1867)

Mostly in the Southern Hemisphere; species 3,—*L. scolopendra* Dum., *L. ochroleuca* Lindb. and *L. pruinosa* Spruce.

15. **Mastigophora** Nees, Eur Leberm iii, p 95 (1833). Mitt in Hook f Handb N Z Fl p 751

Sendtnera, sect **Mastigophora** G L & N Syn Hep. 241

Species 10–15, scattered; *M. Woodsii* is the only European species.

16. **Isotachis** Mitt in Hook f Handb N Z Fl p 526 (1867) Spruce, Hep Amaz et And. p 337

Species 10–15, mostly in the Southern Hemisphere.

TRIBE III LEPIDOZIEÆ.

17. **Lembidium** Mitt in Hook f. Handb N Z Fl p 754 (1867)

A small genus confined to the islands of the South Seas; 3 species are known,—*L. nutans* Mitt of New Zealand, *L. ventrosum* Mitt. of Kerguelen Land, and *L. dendroides* Carrington & Pearson of New South Wales.

18. **Mytilopsis** Spruce, "On Cephalozia" (1882), Hep. Amaz et And. p 387.

Contains one South American species.

19 **Micropterygium** Lindenb in G L & N. Syn Hep. p. 238 (1845).

Species 5–10, mostly in tropical America.

20. **Bazzania** S F. Gray, Nat. Arr. Br. Pl. i, p. 704 (1821) · Spruce, Hep. Amaz et And. p. 366: Underw Cat. Hep p. 82
Pleuroschisma, sect. **Pleuroschismotypus** Dum Syll Jung p 70 (1831).
Pleuroschisma Dum. Rev. des Genres, p. 19 (1835), Hep. Eur. 102
Herpetium, sect. **Mastigobryum** Nees, Hep. Eur iii, p. 43
Mastigobryum Nees in G L & N. Syn. Hep p 214

Species 100–125, especially numerous in tropical regions; the commonest northern species is *B. trilobata* S. F. Gray.

21. **Spruceella** Steph in Engler's Bot Jahrb. viii, p 92 (1887), Hedwigia, xxx, p. 215.

Species 1, *S. succida* (*Lepidozia succida* Mitt.) of western Africa.

22. **Lepidozia** Dum Rev des Genres, p. 19 (1835), Hep Eur p. 109 G L & N. Syn Hep p 200
Pleuroschisma, sect. **Lepidozia** Dum Syll Jung p. 69
Herpetium, sect **Lepidozia** Nees, Hep. Eur. iii, p. 31

Species 50–75, most abundant in tropical regions; the typical *L. reptans* Dum. is the most frequent northern species.

23. **Arachniopsis** Spruce, "On Cephalozia" (1882), Hep Amaz et And p 354

Contains 3 South American species.

24. **Cephalozia** Dum Rev. des Genres, p 19 (1835), Hep Eur p 87 Spruce, "On Cephalozia", Hep. Amaz et And p 388
Jungermannia, sect **Cephalozia** Dum Syll Jung p. 60
Jungermanniæ sp G. L. & N Syn Hep p 131
Zoopsis Hook. f & Tayl Crypt Ant p. 55 (1845)
Trigonanthus Spruce, Trans Bot. Soc Edin iii, p 207 (1850)

A widely distributed genus of 40–50 species; it may be divided into the following subgenera (most which were first proposed by Dr. Spruce):—*Protocephalozia*, *Pteropsiella*, *Zoopsis*, *Alobiella*, *Eucephalozia*, *Cephaloziella* and *Prionolobus*.

25. **Herpocladium** Mitt. in Jour. Linn Soc xv, p 69 (1877)

A small genus of the South Pacific.

26. **Odontoschisma** Dum. Rev des Genres, p. 19 (1835).
Pleuroschisma, sect. **Odontoschisma** Dum. Syll. Jung p. 68.
Sphagnœcetis Nees in G. L & N. Syn. Hep. p. 148 (1845)
Cephalozia, sect **Odontoschisma** Spruce, "On Cephalozia"

Species 10–15, scattered; the typical *O. Sphagni* occurs in both Europe and America.

27. **Hygrobiella** Spruce, "On Cephalozia" (1882).

Species 3,—*H. laxifolia*, *H. myriocarpa* and *H. Nevicensis*, all of northern regions.

28. **Pigafettoa** Mass in Nuovo Gior. Bot Ital xvii, p 237 (1885).

Consists of a single Patagonian species, *P. crenulata.*

29. **Pleuroclada** Spruce, "On Cephalozia"

Species 2,—*P. albescens* and *P Islandica* of Arctic regions.

30. **Anthelia** Dum Rev des Genres, p 18 (1835), Hep Eur p. 97 · Spruce, "On Cephalozia"

Jungermannia, sect **Anthelia** Dum Syll Jung p 63.

Contains 4 species, mostly of northern regions ; *A. julacea* Dum. is the typical species.

31 **Blepharostoma** Dum Rev des Genres p 18 (1835), Hep Eur p 94 · Spruce "On Cephalozia Underw Cat Hep p 80

Jungermannia, sect **Blepharostoma** Dum Syll. Jung p 18.

Jungermanniæ sp G L & N Syn Hep p 144.

Chætopsis Mitt Jour Linn Soc. viii, p 51 (1864).

Contains 2 species,—the widely distributed *B. trichophyllum* Dum. and *B. palmatum* Lindb. of Australia and New Zealand.

32. **Chandonanthus** Mitt in Hook f Handb N Z Fl p 753 (1867) Lindb in Act Soc Sc Fenn x, p 517 (1875)

Anthelia Dum in part

Includes *C. setiformis* Lindb. of northern regions, *C. squarrosa* of New Zealand, and a few other species.

33. **Adelanthus** Mitt in Jour Linn Soc vii, p 243 (1863). Dum Hep Eur. p 46

The original species of Mitten were *A. falcatus*, *A. Magellanicus*, *A. Lindbergianus* and *A. decipiens.* Since his publication of the genus a few other species have been added. The genus is mostly tropical, but *A. decipiens* occurs in Ireland.

34. **Anomoclada** Spruce, Jour of Bot xiv (1876), Hep. Amaz et And p 407.

Species 1, *A. mucosa* of South America.

TRIBE IV. SACCOGYNEÆ.

35. **Kantia** S. F. Gray, Nat Arr Br. Pl. i, p. 706 (1821): Underw in Gray's Manual, Ed. vi, p. 713

Cincinnulus Dum Comm bot p 113 (1822), Syll. Jung. p. 72; Rev des Genres, p 21; Hep Eur p 115

Calypogeia (sect B) Raddi, Jung Etr. in Mem. Mod. xviii, p. 44 · G. L & N. Syn. Hep. p. 198.

Species 10–15, scattered ; the typical *K. Trichomanis* occurring in both Europe and America.

36. **Saccogyna** Dum. Comm. bot. p. 113 (1822); Syll Jung p. 74; Rev. des Genres, p. 21; Hep. Eur. 117: G. L & N. Syn. Hep. p. 194

Sykorea Corda in Opiz. Naturl. p 652 (1829)

Species 3,—*S. viticulosa* Dum. of Europe, *S. australis* Mitt. of the South Pacific, and *S. jugata* Mitt. of Samoa.

37. **Geocalyx** Nees, Eur. Leberm i, p 97 (1833)· Dum Rev des Genres, p. 22; Hep Eur. p. 118: G L & N. Syn. Hep p 194

Contains the common *G. graveolens* Nees and a doubtful West Indian species. The genus is included by Carrington and Lindberg under *Saccogyna*.

TRIBE V. JUNGERMANNIEÆ.

38. **Scapania** Dum. Rev. des Genres, p 14 (1835); Hep Eur. p. 33: G. L & N Syn. Hep p. 61.

Radula, sect **Scapania** Dum. Syll Jung. p. 38

Candollea Raddi, in part.

Martinellia S. F. Gray, in part: Lindb. in Acta Soc Fenn x, p 518

Species 30–40, most numerous in northern regions; *S. undulata* and *S. nemorosa* are common and typical species.

39. **Schistocalyx** Lindb in Jour. Linn Soc. xiii, p 185 (1872), Acta Soc Sc Fenn. x, p. 519.

Blepharidophyllum Ångstr. in Öfv. Vet.-Akad. Forh. xxx, p. 151 (1873).

A small subtropical genus proposed for *Scapania chloroleuca*, *S. densifolia* and their near allies.

40. **Diplophyllum** Dum. Rev des Genres, p. 15 (1835); Hep Eur p. 47: Lindb. in Acta Soc. Sc. Fenn. x, p. 522: Underw. in Gray's Manual, Ed vi, p. 715.

Jungermannia, sect **Diplophyllum** Dum. Syll Jung. p. 44.

Jungermanniæ sp. G. L & N. Syn. Hep. p. 76.

Scapaniæ sp. Mitt. in Hook. f. Fl. Tasm. ii, p. 233

A small genus of which the typical species is *D. albicans* Dum. As defined by Dumortier, the genus includes *Jungermannia*, sect. *Sphenolobus* Lindb.

41. **Clasmatocolea** Spruce, Hep. Amaz. et And. p 440 (1885)

A South American genus of 2 species.

42. **Lophocolea** Dum. Rev. des Genres, p. 17 (1835); Hep. Eur p. 83: G L. & N. Syn. Hep. p. 151.

Jungermannia, sect. **Lophocolea** Dum. Syll Jung p. 59.

Species 50–75, especially numerous in tropical regions; *L. bidentata* and *L. heterophylla* are typical northern species.

43. **Diploscyphus** De Not. Mem. Acad. Turin (1874).

Species 1, *D. Borneensis* of Borneo.

44. **Chiloscyphus** Corda in Opiz. Naturl. p. 651 (1829): Dum. Syll. Jung. p. 67; Rev. des Genres, p. 19; Hep. Eur. p. 100: G. L. & N. Syn. Hep. p. 171.

A widely distributed genus of 30–50 species, the typical one being *C. polyanthos* Corda.

45. **Notoscyphus** Mitt. in Seemann, Fl. Vitiensis (1868).

A small genus of the Southern Hemisphere.

46. **Psiloclada** Mitt. in Hook. f. Fl. Nov. Zel. ii, p. 143 (1853); in Hook. f. Handb. N. Z. Fl. p. 518.

Species 1, *P. clandestina* of New Zealand and Tasmania.

47. **Plagiochila** Dum. Rev des Genres, p. 14 (1835); Hep. Eur. p. 42: G. L. & N. Syn. Hep. p. 22.

Radula, sect. **Plagiochila** Dum. Syll. Jung. p. 42.
Candollea Raddi, in part.
Martinellia S. F. Gray, in part.
Pedinophyllum Lindb. Bot. Not. 1874, p. 155 and in Act. Soc. Sc. Fenn. x, p. 504 (1875).

Species 125–150, very numerous in tropical regions; *P. asplenoides* is a common northern species.

48. **Mylia** S. F. Gray, Nat. Arr. Br. Pl. i, p. 693 (1821): Lindb. in Act. Soc. Sc. Fenn. x, p. 525: Underw. in Gray's Manual, Ed. vi, p. 717.

Jungermanniæ sp. G. L. & N. Syn. Hep. p. 82.
Leptoscyphus Mitt. in Hook. Jour. of Bot. iii, p. 358 (1851), in part.
Leioscyphus Mitt. in Hook. f. Fl. N. Zel. ii, p. 134 (1855), in part.
Coleochila Dum. Hep. Eur. p. 105 (1874).

A small genus of northern regions; founded upon *Jungermannia Taylori* Hook. and the allied *J. anomala* Hook.

49. **Leptoscyphus** Mitt. in Hook. Jour. of Bot. iii, p. 358 (1851), in part.

Leioscyphus Mitt. in part.

A small genus occurring in tropical and south temperate regions; *L. fragilifolius* is one of Mitten's original species.

50. **Harpanthus** Nees, Eur. Leberm. ii, p. 351 (1836): G. L. & N. Syn. Hep. p. 689: Dum. Hep. Eur. p. 66.

Pleuranthe Tayl. in Hook. Lond. Jour. Bot. v, p. 282 (1846): G. L. & N. Syn. Hep. p. 689 (1847).

Species 2,—*H. Flotovianus* Nees and *H. scutatus* Spruce of Europe and America.

51. **Liochlæna** Nees in G. L. & N. Syn. Hep. p. 150 (1845).

Aploziæ sp. Dum. Hep. Eur. p. 58.

Contains 2 or 3 species, the typical one being *L. lanceolata* of Europe and America.

52. **Symphyomitra** Spruce, Hep. Amaz. et And p 503 (1885).

A small South American genus.

53. **Jungermannia** (Rupp) Mich. Nov. Gen. (1729) G L. & N Syn. Hep. p. 78. p. 73.

Widely distributed; species 150–200. In its restricted sense, the genus may be divided into the following subgenera:—*Aplozia* Dum. (*Jungermannia* proper), *Lophozia* Dum., *Anastrophyllum* Spruce, *Sphenolobus* Lindb. and *Gymnocolea* Dum. The name "Jungermannia" was first proposed by Ruppius, but Lindberg states that none of Ruppius' original species are now retained in the genus.

54. **Syzygiella** Spruce. Jour of Bot. xiv (1876); Hep. Amaz et And p. 499.

A genus of tropical America, species 5 or 6.

55. **Temnoma** Mitt. in Hook f. Handb N. Z Fl. p 753 (1867)

A genus of a few mostly southern species, founded upon *Jungermannia pulchella* and *J. quadrifida*.

56. **Gymnoscyphus** Corda in Sturm. deuts krypt fasc 25 p. 158· Dum Rev des Genres, p. 16; Hep Eur. p. 112; G L. & N. Syn Hep p 191

Species 1, *G. repens* of Europe.

TRIBE VI. CŒLOCAULEÆ.

57. **Schistochila** Dum Rev des Genres, p. 15 (1835)
Gottschea Nees in G. L & N. Syn Hep p. 13 (1844)

A beautiful genus, mostly confined to the Southern Hemisphere; species 30–40.

58. **Marsupella** Dum. Comm. bot p. 114 (1822), Rev des Genres, p 23, Hep Eur. p. 125 Spruce, Revue Bryol viii p 89 Underw in Gray's Manual, Ed vi, p 721.
Sarcoscyphus Corda in Opiz Naturl p. 652 (1829). G L. & N Syn Hep p. 6
Marsupia Dum. Syll. Jung. p 77.
Nardia S. F. Gray, in part.

A small genus of northern regions; *M. emarginata* and *M. sphacelata* are widely distributed species.

59. **Southbya** Spruce in Trans. Bot. Soc Edin iii, p. 197 (1850) Dum. Hep. Eur. p. 133.

A northern genus of 3–5 species.

60. **Arnellia** Lindb. Kongl. Svenska Vet-Akad xxiii, No. 5 (1889)

Species 1, *A. Fennica* of northern regions.

61. **Nardia** S. F. Gray, Nat Arr. Br. Pl. i, p. 694 (1821): Spruce, Revue Bryol. viii, p. 89: Underw. in Gray's Manual, Ed. vi, p 721.

Mesophylla Dum Comm. bot. p. 112 (1822); Syll Jung p. 80; Rev. des Genres, p. 24; Hep. Eur. p. 129

Alicularia Corda in Opiz Naturl. p 652 (1829) Dum Syll. Jung. p. 79; Hep. Eur. p 131. G. L. & N Syn Hep p 10.

Solenostoma Mitt Jour. Linn Soc viii, p 51

Jungermanniæ sp G L & N Syn. Hep. et Auctt

Aploziæ sp Dum Hep Eur

A widely distributed genus of 15–25 species. As restricted by Spruce, l. c., the genus may be divided into the following subgenera:—*Eunardia* Spruce, *Eucalyx* Lindb., *Apotomanthus* Spruce and *Chascostoma* Lindb.

62. **Gymnomitrium** Corda in Opiz Naturl p. 651 (1829)· G L & N. Syn. Hep p. 2

Cesia S F Gray, Nat Arr Br Pl i, p 705 (1821), not **Cæsia** R Br. (1810).

Acolea Dum Syll Jung p 76 (1831), Hep Eur p 121.

Species 10–20, occurring in cold regions; *G. concinnatum* is a common Alpine species.

63. **Prasanthus** Lindb Kongl Svenska Vet-Akad xxiii, No. 5 (1889).

Species 1, *P. Suecicum* of northern Europe and Asia.

64. **Dichiton** Mont Sylloge Crypt p 52 (1856)

Species 1, *D perpusillum* of Algeria.

TRIBE VII. ACROBOLBEÆ.

65. **Lindigina** Gottsche. Ann d Sc Nat. 5me série, T i, p. 137 (1864): Mitt. Jour Linn. Soc xvi, p 157

Lindigia Gottsche, Mexik Leverm p 216 (1863) non Hampe.

Gymnanthe Tayl in part Mitt. in Hook f Handb. N Z. Fl. p. 519

Podanthe Tayl in Drumm Swan River Crypt (1846): G L & N. Syn. Hep. p. 789, not **Podanthes** Haw Syn Pl Succ (1812)

Lethocolea Mitt in Hook f Handb N Z Fl p. 753.

8 species are enumerated by Mitten, the original ones being *L. Liebmanniana* and *L. Granatensis* of Gottsche.

66. **Acrobolbus** Nees in G L & N Syn Hep p 5 (1844).

Gymnanthe Tayl. in part G. L & N Syn Hep p 192: Dum· Hep Eur. p. 119.

Species 1, *A. Wilsoni* Nees of Europe and South America.

67. **Tylimanthus** Mitt in Hook f Handb N. Z Fl p. 753 (1867).

Gymnanthe Tayl in Lehm. pug pl viii. p. 1 (1844), not **Gymnanthes** Sw. (1788): G. L & N. Syn. Hep. p. 192

A small tropical or subtropical genus, proposed by Mitten for *Gymnanthe saccata*.

68. **Balantiopsis** Mitt. l. c p. 753.
Gymnanthe Tayl. in part.

Mitton gives 2 species,—*B. diplophylla* and *B. erinacea.*

69. **Marsupidium** Mitt l. c. p. 753.
Gymnanthe Tayl. in part.

A small genus of the South Pacific; the original species are *M. Orvilleanum*, *M. setulosum* and *M. Knightii.*

70. **Calypogeia** (sect. A) Raddi, Jung. Etr in Mem. Moden. xviii, p 42 (1820) Dum. Rev. des Genres, p. 21; Hep. Eur p. 113.
Gongylanthus Nees, Eur. Leberm ii, p. 405 (1836): G. L & N. Syn Hep p. 196

A genus of 2–5 species; the European *C. ericetorum* and *C. flagellifera* are Raddi's typical species.

TRIBE VIII. FOSSOMBRONIEÆ.

71. **Scalia** S F Gray, Nat Arr Br Pl i, p. 704 (1821) Carringt Brit Hep p. 1
Mniopsis Dum Comm bot p 114 (1822); Syll. Jung. p. 75; Rev des Genres, p 22; Hep. Eur p. 120.
Haplomitrium Nees, Eur Leberm i, p 109 (1833) G L & N Syn. Hep p 2

Species 3,—*S. Hookeri* of Europe, and 2 species of tropical America.

72. **Rhopalanthus** Lindb. Manip. Musc Scand p. 390 (1874).

Species 1, *R. mnioides* of Japan.

73. **Fossombronia** Raddi, Jung Etr. in Mem. Moden. xviii, p. 40 (1820)· Dum. Rev. des Genres, p 11; Hep Eur pp. 13, 173: G. L. & N Syn. Hep p. 467
Codonia Dum. Comm. bot. p 111 (1822), Syll. Jung p 29.

Species 10–20, scattered; the typical *F. pusilla* occurs in Europe.

74. **Noteroclada** Tayl. Hep. Antarc. in Lond. Jour. Bot. 1844, p. 478.
Androcryphia Nees, G. L. & N. Syn. Hep p. 470 (1846).

A small genus, mostly confined to the Southern Hemisphere.

75. **Petalophyllum** Gottsche in G. L. & N. Syn. Hep. p. 472 (1846).
Codonia Dum Hep. Eur. p 16 (1874).

Species 4–8, scattered; *P. Ralfsii* occurs in the British Isles.

76. **Calycularia** Mitt. in Journ Linn. Soc. v. p. 122 (1861).

A small tropical genus of South Asia, etc.

77. **Calobryum** Nees in Lindl. Introd. Ed. ii, p. 414; G. L & N Syn. Hep. p. 507.

A very doubtful genus containing one species, *C. Blumii* of Java.

78. **Treubia** Göbel, Ann Jard Bot Buitenzorg ix (1890)

A small Javanese genus

79 **Podomitrium** Mitt in Hook f Fl Nov Zel ii p 164 (1853), in Handb Z Fl p N 541

Species 1, *P Phyllanthus* of Tasmania and New Zealand.

80 **Pallavicinia** S F Gray Nat Arr Br Pl i p 775 (1821) Lindb in Act Soc Sc Fenn x, p 540 Underw in Gray's Manual Ed vi p 723
Dilæna Dum Comm bot p 114 (1822) Rev des Genres p 25, Hep Eur p 136
Diplomitrium Corda in Opiz Naturl p 653 (1829)
Diploloena Dum Syll Jung p 82 (1831)
Cordæa Nees in Bot Zeit 1833 p 101
Blyttia Endl Gen Pl p 1339 (1840) G L & N Syn Hep p 474
Steetzia Lehm Pl Preiss ii p 129 (1846)
Morckia Gottsche in Rabenh Hep Eur Fasc n 295
Mittenia Gottsche in Ann des Sc Nat 5me serie T i p 177 (1864)

Species 10–15, scattered, the original *P Lyellii* is common and widely distributed

81 **Hymenophyton** Dum Rev des Genres p 25 (1835)
Umbraculum Gottsche in Mohl & Schlecht Bot Zeit 1861, pp 1–3, Ann des Sc Nat 5me serie, T i, p 180 (1864)

Species 3,—*H. flabellatum* Dum and *H leptopodon* (Tayl.) of New Zealand, and *H Mülleri* (Gottsche) of Australia

82 **Symphyogyna** Mont & Nees in Ann des Sc Nat 2me serie, I v p 66 (1836) G L & N Syn Hep p 479

Species 20–30; mostly in the Southern Hemisphere.

83. **Pellia** Raddi, Jung Etr in Mem Moden xviii p 45 (1820) Dum Rev des Genres p 27 Hep Eur p 114 G L & N Syn Hep p 488
Scopulina Dum Comm bot p 115, Syll Jung p 87

Species 3–5, scattered; *P epiphylla*, the original species, is widely distributed

84. **Blasia** Mich Nov Gen p 14 (1729) G L & N Syn. Hep p. 491 Dum Hep Eur. p. 134

Species 1, *B. pusilla* Linn. of northern regions.

TRIBE IX. MONOCLEÆ.

85. **Monoclea** Hook Musc Exot t 174 (1820) G. L & N Syn Hep p 508

Species 2,—*M. Forsteri* Hook. of New Zealand and *M. Gottschei* Lindb. of South America.

TRIBE X. METZGERIEÆ.

86. **Metzgeria** Raddi, Jung Etr in Mem. Moden xviii, p 45 (1820): Dum Rev. des Genres, p. 26; Hep Eur. p 138: G L. & N Syn Hep p 501.

Fasciola Dum. Comm. bot. p. 114.

Echinogyna Dum. Anal. fam. p 60; Syll. Jung p 83.

Lindberg enumerates 11 species in his monograph of the genus; the original *M. furcata* and *M. pubescens* are common in Europe.

TRIBE XI. ANEUREÆ.

87. **Aneura** Dum Comm. bot. p. 115 (1822), Syll Jung. p 85; Rev. des Genres, p 26; Hep Eur. p 140: G. L. & N Syn. Hep p 493.

Rœmeria Raddi, Jung. Etr. in Mem Mod. xviii, p. 46, not **Rœmeria** Medik.

Riccardia S. F Gray, Nat Arr Br Pl i, p 683 (1821), not **Richardia** Kunth in Mém Mus Paris, iv, p 430 (1818).

Sarcomitrium Corda in Sturm Deutschl Fl. 2 fasc 26 and 27, p. 119.

The genus includes the following,—

Acrostolia Dum Rev des Genres, p. 26 (**Pseudoneura** Gottsche, Mexik. Leverm).

A widely distributed genus of 20–30 species, the typical *A. pinguis* occurring in Europe and America.

ORDER II. ANTHOCEROTACEÆ.

88. **Dendroceros** Nees in G. L. & N. Syn. Hep p. 579 (1846)

Species 10–15, mostly tropical.

89. **Anthoceros** Mich. Nov Gen. p. 11 (1729)· G. L. & N Syn. Hep. p 582.

Species 20–30, most numerous in tropical regions; *A. lævis* and *A. punctatus* are the commonest northern species.

90. **Notothylas** Sulliv. Mem Am Acad. n ser. iii, p 65 (1846): Dum Hep Eur. p. 161.

Carpolipum Nees in G. L. & N Syn Hep. p. 591.

Chamæceros Milde in Nov. Act N. C. (1856).

A small genus of Europe and North America; *N. orbicularis* Sulliv. is an original species.

ORDER III. MARCHANTIACEÆ.

TRIBE I. MARCHANTIEÆ.

91. **Marchantia** Marchant. f. in Act. Gall. (1713): G. L. & N. Syn Hep. p 521; Dum. Hep. Eur. p. 150.

Widely distributed; species 25–30; *M. polymorpha* L. is the commonest.

92. **Preissia** Corda in Opiz Naturl p 647 (1829) G L & N Syn Hep p 521.
Chomiocarpon Corda, l c p 647

A small genus, mostly found in northern regions; *P. commutata* Nees is the most widely distributed species

93 **Fimbriaria** Nees, Hor phys Berol p 44 (1820) G L & N. Syn Hep p 555
Hypenantron Corda in Opiz Naturl p 648 (1829)

Species 25–30, scattered; *F. tenella* is a common American species.

94. **Conocephalus** Necker, Elem Bot iii, p 344 (1790) Dum Hep Eur p 154.
Fegatella Raddi in Opusc scient d Bot ii p 356 (1818) G L & N Syn Hep p. 546
Hepatica Mich Nov Gen (non Dill)

Contains 2 species,—the cosmopolitan *C. conicus* Dum. and *C. Japonicus* (Steph).

95 **Sandea** Lindb Acta Soc pro F et Fl Fenn T ii, N 5, p 3 (1884)

Species 1, *S. supradecomposita* Lindb. of Japan and India

96. **Sauteria** Nees Eur Lebern iv, p 139 (1838) G L & N Syn Hep p 541 Lindb Acta Soc pro F et Fl Fenn T ii N 3, p 7

Contains the typical *S. alpina* Nees and a few doubtful species.

97. **Peltolepis** Lindb Bot Notis 1877, p 73, Acta Soc. pro F et Fl Fenn T ii, N 3, p 3

Species 1, *P grandis* of Northern Europe.

98 **Clevea** Lindb Not Soc pro F et Fl Fenn ix, p 289 (1868), Acta Soc pro F et Fl Fenn T ii N 3 p 10 Dum Hep Eur p 149
Exormotheca Mitt in C Godman's Nat Hist. Azores, p 325 (1870)

A small genus of which the typical species is *C. hyalina* of Europe and Greenland.

99. **Athalamia** Falconer in Trans Linn Soc xx, P 3, p 397 (1851)

Species 1, *A pinguis.*

100 **Grimaldia** Raddi in Opusc scient d Bot ii, p. 356 (1818)· G L. & N. Syn Hep p 549 Dum Hep Eur. p 156
Duvalia Nees in Mag d nat fr zu Berl p. 271 (1817) G L. & N Syn Hep. p. 553, not **Duvalia** Haw. Syn Pl Succ. 414 (1812).

A small genus of Europe and America; the best known species are *G. barbifrons* and *G. rupestris.* The old genera *Grimaldia* and *Duvalia* are here united in accordance with the views of Lindberg, Underwood and others. (See Bot. Gazette, xiv, p. 197.)

101. **Cryptomitrium** Aust. in Underw. Cat. Hep. p. 36 (1884).

Species 1, *C. tenerum* of Mexico and California.

102. **Asterella** Beauv. in Encycl. meth. suppl. i, p. 502 (1810): Dum. Hep. Eur. p. 154: Underw. Cat. Hep p. 37.

Reboulia Raddi in Opusc. scient. d. Bot. ii, p. 56 (1818): G. L. & N. Syn. Hep. p. 547

A small genus of which the typical species is *A. hemisphærica* of Europe and North America.

103. **Askepas** Griff. Notulæ, p. 341 (1849): Mitt. Jour. Linn. Soc. v, p. 127

Species 1, *A. brevipes* of India.

104. **Dumortiera** Nees in Nov. Act. Acad Cæs. Leop. xii, P. 1, p. 410 (1823): G. L. & N. Syn Hep. p. 542.

Species 5-10, scattered; the typical *D. hirsuta* is found in both Europe and America.

105. **Rhacotheca** Bischoff in Hochst. & Seub Fl. Azor p. 12, t. 14 (1846): G. L. & N. Syn. Hep. p 573.

Species 1, *R. Azorica.*

TRIBE II. LUNULARIEÆ.

106. **Lunularia** Mich Nov Gen. p. 4 (1729): G. L & N. Syn Hep. p 510

Species 1, the common *L. vulgaris.*

107. **Aitonia** Forster, Char. gen. pl. p. 147, n. 74 (1776): Lindb. in Act Soc. Sc. Fenn. x

Otiona Corda in Opiz Naturl. i, p. 648 (1829). Dum. Hep. Eur p 148.

Plagiochasma Lehm. et Lindenb. in Lehm. Pug. pl. iv, p. 13: G. L & N. Syn. Hep. p. 511.

Species 15–20, mostly in warm regions.

TRIBE III. TARGIONIEÆ.

108. **Targionia** Mich. Nov. Gen. p 3 (1729): G. L. & N. Syn. Hep. p 574.

A small genus, most frequent in warm countries; the original *T. hypophylla* occurs in Europe and America.

109. **Cyathodium** Kunze in Lehm. Pug. pl vi, p. 17 (1834): G. L. & N Syn. Hep. p. 577.

Synhymenium Griff. Notulæ, p. 344 (1849): Mitt. in Jour. Linn Soc. v, p 124. (See Stephani in Hedwigia, xxvii, p. 250.)

Monoselenium Griff. l. c. p. 341: Mitt. l. c. p. 127.

Species 1, the tropical *C. cavernosum.*

ORDER IV. RICCIACEÆ.

TRIBE I. RICCIEÆ.

110. **Boschia** Mont. Ann des Sc. Nat. 4me série, T v, p. 351 (1856).

Species 1, *B Weddellii* of Brazil.

111. **Riccia** Mich. Nov Gen p. 107 (1729): G L. & N. Syn. Hep. p. 598.

Widely distributed; species 50–60. The genus may be divided into the subgenera *Lichenodes*, *Spongodes*, *Ricciella* and *Ricciocarpus*, the last two of which are considered distinct genera by Dumortier and others.

112. **Tessellina** Dum Comm bot p 78 (1822); Hep. Eur. p. 164.
Oxymitra Bisch in Lindenb. Syn Hep Eur. p. 124 (1829): G L. & N. Syn. Hep p. 597
Rupinia Corda in Opiz Naturl p 650 (1829).
Pyonoscenus Lindb in Öfv. Vet-Akad Förh xix, p 606 (1862).

Species 1, *T. pyramidata* of Europe, etc.

113. **Corsinia** Raddi in Opusc. scient. d. Bot (1818). G. L. &. N. Syn Hep p. 596

Species 1, *C. marchantioides* of Europe.

114. **Myriorrhynchus** Lindb Acta Soc. pro F et Fl. Fenn. T ii, N. 5, p. 7 (1884)

Species 1, *M. fimbriatus* Lindb. (*Riccia fimbriata* Nees) of South America.

TRIBE II. SPHÆROCARPEÆ.

115. **Riella** Mont. Sylloge Crypt p. 94 (1856): Dum. Hep Eur, p. 163.
Durieea Bory & Mont Compte. rendu des séances de l'Acad. des Sciences (1843): G. L. & N. Syn Hep p. 593.

A small genus of Europe and Northern Africa.

116. **Sphærocarpus** Mich. Nov. Gen. p. 4 (1729): G. L & N. Syn. Hep p. 594.

A small genus of Europe and North America; *S. terrestris* is the most widely distributed species.

117. **Thallocarpus** Lindb. in Bull Torr Bot. Club, vi, p. 21 (1875): Underw Cat. Hep. p. 29
Cryptocarpus Aust. in Proc Phil. Acad. Dec 1869, p. 231.

Species 1, *T. Curtisii* Aust. of the Southern United States.

INDEX.

SYNONYMS IN ITALICS.

XVII.—On the Ferments contained in the Juice of the Pineapple (*Ananassa sativa*), together with some Observations on the Composition and Proteolytic Action of the Juice. By R. H. Chittenden, assisted by E. P. Joslin and F. S. Meara.

Some time ago the writer's attention was called to the fact that Señor V. Marcano,* of Venezuela, had discovered the existence of a proteid-digesting principle in plants of the order Bromeliaceæ, of which the pineapple is a well known representative, and that the juice of the latter fruit was being made use of as a digestive agent in the preparation of pre-digested foods.† So far as the writer is aware, there is no scientific record of this discovery other than in a short note contained in a recent number of a pharmaceutical journal,‡ in which attention is simply called to Marcano's discovery and the name "*bromelin*" suggested as an appropriate title for the hypothetical ferment.§ Apparently, no study has been made of the nature of the ferment presumably present in the juice, its mode of action, or the character of the products resulting from such action.

From a physiological standpoint the discovery of any ferment, either in the vegetable or animal kingdom, is a matter of considerable importance, especially so in the plant kingdom, since the feeling is widely gaining ground that proteid-splitting ferments must play an important part in rendering the food material of plants available. As in the animal kingdom, proteid food to be available for the needs of the plant must be transformed into soluble forms fitted for absorption and circulation. Hitherto, the best known illustration of such a vegetable proteolytic ferment has been *papaïn*, present in the juice of the papaw plant, but in the discovery of the proteolytic action of pineapple juice we have what promises to be an equally prominent illustration and one, moreover, which constitutes an addi-

* Recently deceased.

† By the Mosquera-Julia Food Co.

‡ Bulletin of Pharmacy, vol. v, p. 77, 1891.

§ Since the above was written the writer's attention has been called to the following reference contained in the Botanisches Centralblatt, No. 44, 1891: "E. Kayser. Note sur les ferments de L'ananas, Annales de l'Institute Pasteur, 1891, No. 7." To how great an extent this communication treats of the work about to be described the writer has at present no means of judging, as the above periodical is not at hand.

tional reason for believing in the probable wide-spread distribution of proteid-digesting principles throughout the vegetable kingdom.

The proteid-digesting power* of fresh pineapple juice is something quite remarkable in its intensity; it is moreover a constant feature and one which admits of easy demonstration. During the past few months great numbers of ripe pineapples have been examined in the writer's laboratory and in no instance has the juice failed to show marked proteolytic power, as evidenced by its ready solvent action on blood fibrin and other forms of proteid matter.

In addition to this proteid-digesting power, we have discovered that the juice also possesses in a remarkable degree the power of curdling or clotting milk. Neutralized pineapple juice added to milk warmed at 40° C., quickly brings about a separation of the casein, in the form of a thick clot or curd, the action being apparently exactly analogous to that of the rennet-ferment or rennin. Boiling the neutralized juice prior to its addition to the milk prevents this separation of a clot, and hence the action in question must be due to the presence of a rennet-like ferment. This ferment, indeed, we have been able to separate from the juice, together with the proteolytic ferment, by saturation of the fluid with ammonium sulphate and with this preparation we have substantiated its milk-curdling properties.

General character of pineapple juice.

As is well known, the pineapple is an exceedingly juicy fruit, an average sized one of 1100 grams yielding, after chopping the tissue and subjecting it to sufficient pressure, 600–800 cubic centimeters, or considerably more than half its weight, of juice. As it flows from the press the fluid has a somewhat turbid appearance, not easily removed by filtration through paper, but eventually, as the pores of the paper become somewhat filled up, a perfectly clear yellowish colored filtrate is obtained, of very decided acid reaction and with an average specific gravity of 1043. The acidity is very pronounced, but naturally quite variable, being dependent in part upon the ripeness of the fruit. A determination of the acidity of twenty distinct samples of filtered juice showed an average acidity equivalent to 0·45 per cent. hydrochloric acid (HCl), the extremes being 0·28 per cent. and 0·65 per cent., calculated as HCl. The content of proteid matter in the clear filtered juice is quite small. Heated with Millon's reagent, a fairly strong proteid reaction is

* This was referred to by the writer in a paper read before the Philadelphia County Medical Society, May 13, 1891, an abstract of which was published in the Medical News, vol. lviii, p. 719.

obtained, the intensity of which, however, appears to be due in part to the presence of tyrosin or some related soluble body.

With acetic acid alone no precipitate is produced, but with acetic acid and potassium ferrocyanide a slight precipitate or turbidity results. With the biuret test, the reaction is in great part vitiated by the large amount of sugar present in the juice, which gives rise to an intense yellowish-brown color on addition of the strong alkali.

Neutralization of the acid juice with sodium carbonate fails to give any neutralization precipitate whatever, thus showing the absence of acid-albumin. Concentrated nitric acid produces in the clear filtered juice a white precipitate soluble in excess of the acid, the fluid taking on a bright yellow color.

Fresh pineapple juice filtered clear and with average acidity, subjected to fractional heat precipitation grows slightly turbid at 60–62° C., the turbidity increasing gradually as the temperature is raised until 75–78° C. is reached, when a small flocky coagulum results. The filtrate from this coagulum on being further heated shows signs of turbidity at about 82° C., increasing with the rise in temperature, without however any distinct signs of flocking until the boiling point is reached. As the fluid commences to boil, but sometimes only after persistent boiling, a fine flocky precipitate separates, which on filtration leaves a perfectly clear fluid. This fluid, free from all matter coagulable by heat, gives with Millon's reagent the usual proteid reaction, while with acetic acid and potassium ferrocyanide, it yields a distinct white precipitate. Concentrated nitric acid alone gives no reaction, but addition of saturated-salt solution with the acid causes a distinct turbidity, which is increased rather than diminished by heat. We have thus evidence of the presence in pineapple juice of what appears to be three distinct proteids; two separable from the acid juice by heat alone, one at about 75° C., the other at 100° C., while the third body is wholly non-coagulable by heat, but is precipitable by acetic acid and potassium ferrocyanide This latter proteid can also be precipitated by saturation of its solution with ammonium sulphate (after removal of the proteids separable by boiling) together with some non-proteid matter present in the juice, and after removal of the ammonium sulphate by dialysis gives the reactions above indicated. It is present only in very small quantity. In some cases, however, this third body is present in the juice in larger quantity, or to express it more exactly, in some specimens the precipitate produced by acetic acid and potassium ferrocyanide in the filtrate from the heat precipitations is considerably more pronounced than first described.

The two precipitates produced by heat alone, viz: at 75–78° C. and at 100° C. are not coagulated proteids in the ordinary sense of the term. Unlike an ordinary coagulum of albumin or globulin, these precipitates, when filtered off and washed with water, dissolve readily and almost entirely in dilute solutions of potassium hydroxide; they are also more or less completely soluble in 0·5 per cent. solution of sodium carbonate, especially if warmed, and are somewhat soluble in 0·2 per cent. hydrochloric acid In strong nitric acid on the other hand, both precipitates are insoluble unless a large quantity of the acid is added. They are likewise insoluble in 10 per cent. solution of sodium chloride. The proteid separable by heat at about 75° C. appears somewhat more soluble in 0·5 per cent. sodium carbonate than the substance separating at 100° C., the latter dissolving completely in 0·5 per cent. sodium carbonate only when the mixture is heated to boiling. The solution of the above precipitates in dilute alkali is not alkali-albumin, although the substance is in part precipitated by neutralization of the alkaline fluid, since nitric acid gives a precipitate apparently wholly insoluble in excess of the acid, even on heating.

These two proteids, when dissolved in potassium hydroxide and tested with a few drops of a dilute solution of cupric sulphate, give a violet rather than a red biuret reaction.

While thus these two proteids precipitated by heat, at 75° and 100° C. respectively, are not exactly akin to an ordinary albumin or globulin in their behavior towards heat, neither do they closely resemble on the other hand an ordinary albumose, like the β phytalbumose of Martin* present in papaw juice, since the precipitates are not readily soluble in nitric acid, even when heated, and when once dissolved are not separable on cooling the solution.

As already stated, the amount of proteid matter in pineapple juice is comparatively small and apparently these two proteids, separable by boiling, compose the greater part of the albuminous matter. The amount was determined by simply heating 100^{cc} of filtered (acid) juice to boiling, collecting the precipitate on a weighed filter, washing it thoroughly with boiling water and drying it at 110° C. until of constant weight. The result showed the presence of only 0·0270 gram in the 100^{cc} of juice, or less than 0·025 per cent.

When *neutralized* pineapple juice is subjected to heat precipitation, the initial turbidity makes its appearance at about 72°–74° C. with separation of flocks at 82°–83° C. The filtrate from this pre-

* Journal of Physiology, vol vi, p. 347.

cipitate remains clear even when the solution is boiled, but a drop or two of acetic acid added to the hot fluid produces a turbidity, which on further heating eventually changes to a flocculent precipitate. In the filtrate from this second precipitate, acetic acid and potassium ferrocyanide show the presence, in small quantity, of what is presumably a non-coagulable proteose. It is thus evident that the presence of acid lowers the temperature at which these bodies are precipitated by heat, and further that the substance precipitated at 100° C. can be made to separate only in the presence of dilute acid. This fact certainly favors the view that the juice contains two distinct proteids precipitable by heat, the one at about 75° C. in an acid solution or 82° C. in a neutral fluid, the other at 100° C. in an acid fluid. On the other hand, the above reactions might be produced by a single substance slowly or incompletely precipitated by heat, analogous to the separation of Martin's* β phytalbumose, which is described as separating in two distinct stages, viz: at from 78°–82° C., and from 83°–95° C. As against this latter view, however, we have the apparent fact that in the pineapple juice, one of the proteids is precipitated from a neutral or acid fluid by heat, the other only from an acid fluid.

Long continued dialysis (10–12 days) of neutralized pineapple juice in running water, protected from putrefaction by addition of thymol, gives little or no separation of any proteid matter. A faint turbidity may appear, but no separation sufficiently large to collect on a filter. Such turbidity as does make its appearance clears up on the addition of a few drops of a strong solution of sodium chloride, or of dilute nitric acid; two reactions equally characteristic of a globulin or of heteroproteose.

Saturation of neutralized, or acid, pineapple juice with pure ammonium sulphate precipitates all of the proteids present in the fluid, together with a small amount of non-albuminous matter. In this precipitate are contained both the proteolytic and rennet-like ferments.

Saturation of neutralized pineapple juice with sodium chloride gives rise to a small flocculent precipitate of proteid matter, which is not at all increased by the addition of acetic acid to the salt-saturated fluid. Addition of ammonium sulphate in substance to the filtrate from the salt-saturation precipitate produces a further precipitate of proteid matter, thus suggesting a possible separation of two distinct bodies. Further, simple boiling of the filtrate from

* Journal of Physiology, vol. vi, p 349.

the sodium chloride saturation produces a flocky precipitate, substantiating this view.

Saturation of the neutralized juice with magnesium sulphate likewise produces a precipitate of proteid matter, somewhat heavier than that induced by saturation with sodium chloride. Addition of crystals of sodium sulphate to the filtrate from the above precipitates causes finally a slight additional separation of flocculent matter containing a little proteid.

Both the sodium chloride precipitate and the magnesium sulphate precipitate are strongly proteolytic.

The general character of these precipitates will be discussed more in detail later on, in connection with the isolation of the proteolytic ferment.

Proteolytic action of fresh pineapple juice under varying conditions.

As already stated, fresh pineapple juice is strongly proteolytic, and its proteid-digesting power is manifested in a neutral, acid, or even alkaline-reacting fluid. In this respect, therefore, the ferment resembles trypsin rather than pepsin.

When blood fibrin is warmed at 40° C., or thereabout, with filtered pineapple juice of average acidity the fibrin swells up somewhat in the acid fluid, then quickly becomes disintegrated and in part dissolved, the initial action certainly being as vigorous as that of a moderately strong solution of pepsin-hydrochloric acid. There invariably remains, however, even after long-continued warming at 40° C., a fairly large insoluble residue, not of unaltered fibrin, but of finely divided antialbumid-like matter more or less soluble in weak alkaline fluids, from which it is reprecipitated by the addition of dilute acid.

Pineapple juice neutralized, or made very faintly alkaline, with dilute sodium carbonate acts apparently in much the same manner as the acid juice, except that in the alkaline-reacting fluid there is less residue of antialbumid-like matter and in the neutralized juice, naturally, an utter absence of any swelling of the fibrin. An examination of the several digestive mixtures, however, shows that the products formed in a neutral or alkaline solution are different somewhat from those formed in an acid-reacting fluid, a point which will be referred to again later on.

One of the most noticeable features in the digestive action of the pineapple ferment is its peculiar softening and disintegration of the proteid matter. This is most noticeable in a neutral solution; thus

when blood fibrin, for example, is warmed with neutralized pineapple juice, or better, with a neutral solution of the isolated ferment there is at first no sign of any digestive action whatever, but on stirring or shaking the mixture, after a sufficient length of time, the fibrin falls to pieces completely disintegrated with the production of a more or less turbid fluid, after which its solution is fairly rapid, although there invariably remains considerable insoluble matter, the same as in an acid mixture. While this action of the ferment resembles somewhat that of trypsin, there is never seen that peculiar eating into the fibrin, so characteristic of the latter ferment; the fibrin never has the appearance of being full of tiny holes, as if bored by a host of worms, so often seen in a trypsin digestion. The pineapple ferment appears simply to soften the fibrin with more or less solvent action at the same time, so that when stirred or pressed it breaks apart into larger or smaller pieces, these in turn undergoing a like change until the fibrin is thoroughly disintegrated and the soluble portion dissolved.

1.—*Influence of the reaction of the fluid.*

As is well known, trypsin* and papain† act best in an alkaline medium; the pineapple ferment on the other hand acts most energetically in a neutral solution, although the ferment is decidedly active in the presence of both acids and alkali carbonate.

In studying the effect of changes in the reaction of pineapple juice on its proteolytic power, or in measuring the proteolytic action of the ferment under varying conditions, the following method was, as a rule, made use of; a given volume of filtered pineapple juice, usually 100 c. c, was warmed at 40° C. for a given length of time with 10 grams of moist, freshly coagulated egg-albumin, which had been completely freed from all soluble matter by thorough washing with hot water. When the period of digestion was completed the undissolved matter was collected on a weighed filter, washed with water until all soluble bodies were removed and then dried at 110° C. until of constant weight. By subtracting the weight of the insoluble residue so obtained from the weight of dry albumin‡ equivalent to the moist albumin used in the experiment, the amount of proteid matter digested, or rather converted into soluble products, was ascertained. Obviously, however, the so-called undissolved portion of

* Studies from the Laboratory of Physiological Chem., Yale University, vol. I, p. 135

† Martin, Journal of Physiology, vol. v, p. 221; vol. vi, p. 336.

‡ Determined by simply drying 10 grams of the sampled coagulated albumin at 110° C until of constant weight

the albumin was in part composed of insoluble antialbumid-like matter, especially when the digestions were carried on in acid or neutral media. The method, however, afforded a fairly accurate means of measuring the proteolytic power of the ferment, as contained in pineapple juice, while the greater resistance of coagulated albumin as compared with blood fibrin seemed to offer advantages in the way of accuracy.

Experiment I.—The pineapple juice employed had an acidity equal to 0·445 per cent. HCl,* requiring 13 c. c. of a 5·0 per cent. solution of Na_2CO_3 to neutralize 100 c. c. The 10 grams of moist coagulum used in each digestive mixture contained 1·3633 grams of dry albumin (at 110° C.). The mixtures were warmed at 40° C. for 3½ hours.

	Pineapple juice.	Reaction	Undissolved albumin	Per cent digested.
A	100 c. c.†	natural acidity	0·8932 gram	34·5
B	100	neutralized	0·8187	40·0

Experiment II.—The acidity of the pineapple juice employed was equal to 0·507 per cent. HCl. Necessary to neutralize 100 c. c., 14·7 c. c. of a 5·0 per cent. solution of Na_2CO_3. Weight of dry albumin equivalent to the 10 grams of moist coagulum used in each mixture, 1·3302 grams. The digestions were carried on at 40° C. for 2 hours.

	Pineapple juice.	Reaction.	Undissolved albumin.	Per cent. digested.
A	100 c. c.	natural acidity	1·0586 grams	20·8
B	100	neutralized	0·9355	29·7

Experiment III.—The acidity of the pineapple juice was not accurately determined. 15 c. c. of a dilute solution of sodium carbonate were required to neutralize 100 c. c. of juice. The weight of dry albumin contained in the 10 grams of moist coagulum used in the digestions was 1·4583 grams. The mixtures were warmed at 40° C. for 5½ hours.

	Pineapple juice.	Reaction	Undissolved albumin.	Per cent. digested.
A	100 c. c.	natural acidity	0·8926 gram	38·8
B	100	half-neutralized	0·8733	40·2
C	100	neutralized	0·8115	44·4

From these results, it is seen that full 40 per cent. or more of coagulated egg-albumin can be converted into soluble products by the pineapple ferment, under the conditions of the above experi-

* Determined by titration with a standard solution of ammonium hydroxide.

† Plus the amount of sodium carbonate solution required for neutralization in B, and of water to make an equal dilution in A.

ments, and further that the neutralized juice is considerably more active than the unneutralized fluid. Apparently, the proteolytic action of the ferment increases with the decrease in acidity, until the neutral point is reached.

With blood fibrin, on the other hand, juice of the natural acidity appears to have a greater digestive power than the neutralized fluid, although on this point we have only a single experiment to offer. This may perhaps be explained simply by the swelling of the fibrin in the dilute organic acid, this condition possibly facilitating the action of the ferment.

Experiment IV.—The acidity of the pineapple juice was equal to 0·525 per cent. HCl. Necessary to neutralize 100 c. c. of filtered juice, 15·2 c. c. 5·0 per cent. solution of Na_2CO_3. Weight of dry albumin contained in 10 grams of moist coagulum, 1·4486 grams. Weight of dry fibrin (at 110° C.) contained in 6 grams of washed blood fibrin,* the amount used in the digestions, 2·5273 grams. The digestive mixtures were warmed at 40° C. for 2 hours.

	Pineapple juice	Reaction	Undissolved proteid	Per cent digested
Blood fibrin	100 c. c.	natural acidity	1·2435 grams	50·8
	100	neutralized	1·4321	43·3
Egg albumin	100	natural acidity	1·0825	28·8
	100	neutralized	1·0096	30·3

The most noticeable feature in this experiment, aside from the point already mentioned, is the far greater digestibility of blood fibrin as compared with egg-albumin, a fact which might naturally be expected, since the same is true in the case of other well-known proteolytic ferments.

The proteids of muscle tissue are likewise more readily digested by pineapple juice than coagulated egg-albumin, full 60 per cent. of the former proteids being converted into soluble products during one hour's warming at 40° C. This is plainly shown in the following experiment, in which also the muscle proteids, like egg-albumin, are seen to be more rapidly digested in the neutralized juice than in the acid fluid.

Experiment V.—The acidity of the pineapple juice employed was equal to 0·507 per cent. HCl. Necessary to neutralize 100 c. c. of juice, 14·7 c. c. of a 5 per cent. solution of Na_2CO_3. Weight of dry

* Washed with water and salt solution, then boiled in water, alcohol, and lastly in water.

proteids contained in 10 grams of prepared muscle* tissue, 2·7258 grams.

	Pineapple juice	Reaction	Undissolved proteid	Per cent digested
½ hour at 40° C	100 c. c	natural acidity	1·8945 grams	30·6
	100	neutralized	1·1366	58·4
1 hour at 40° C	100	natural acidity	1·6368	40·1
	100	neutralized	1·0145	62·8

The acidity of pineapple juice is due to organic acids and acid salts, far weaker in their action on ferments than mineral acids. Addition of dilute mineral acid in small quantity to pineapple juice of natural acidity checks, but does not prevent the digestive action of the ferment. Thus, the addition of an equal volume of 0·2 per cent. hydrochloric acid to pineapple juice diminishes very greatly its digestive power, but does not prevent it altogether. From this we may conclude that pineapple juice can exert its proteolytic power, to a certain extent, when taken into the stomach and mixed with the acid of the gastric juice. Obviously, the addition of an equal volume of 0·2 per cent. hydrochloric acid to neutralized pineapple juice does not necessarily mean the presence of 0·1 per cent. HCl, since the acid may be in great part used up in decomposing the various salts present, and in combining with the various forms of organic matter contained in the juice.

Experiment VI.– The acidity of the pineapple juice employed was equal to 0·288 per cent. HCl. The 10 grams of moist albumin coagulum used in the digestions contained 1·7972 grams of dry albumin. The mixtures were warmed at 40° C. for 17 hours.

	Pineapple juice of natural acidity	Undissolved albumin	Per cent digested
A	100 c. c. + 100 c. c. H_2O	1·2238 grams	32·0
B	100 + 100 0·2 % HCl	1·4673	19·0

Were it not for the large quantities of salts, etc., in pineapple juice the above inhibitory action of the hydrochloric acid on the ferment would be far more pronounced. This is shown by the two following experiments :

By adding about five volumes of 95 per cent. alcohol to pineapple juice, a flocculent precipitate results composed of the proteids of the juice, together with the proteolytic ferment and some salts. On dissolving this precipitate in water a solution is obtained with marked proteolytic power.

* Prepared by soaking chopped muscle tissue, freed from fat and tendons, in water until all blood and soluble extractives were removed.

Experiment VII.—Aqueous solution of the above described alcoholic precipitate. The 10 grams of moist albumin coagulum used in the digestions contained 1·4138 grams of dry albumin. The mixtures were warmed at 40° C. for 4 hours.

	Ferment solution	Reaction	Undissolved albumin	Per cent digested
A	100^{cc} + 100^{cc} H_2O	neutral	1·0881 grams	23·1
B	100 + 100 0·2 % HCl	0·1 % HCl	1·4099	0·3

Thus, with this very impure preparation of the ferment the presence of 0·1 per cent. hydrochloric acid was sufficient to entirely prevent any digestive action whatever. Doubtless, even smaller amounts of acid would have the same influence on the more perfectly isolated ferment.

As already stated, saturation of pineapple juice, either neutralized or of natural acidity, with ammonium sulphate precipitates all or nearly all of the proteids present in the fluid, the precipitate showing by its proteolytic action that it contains the ferment as well. An aqueous solution of such a precipitate, dialyzed to free it from ammonium sulphate, has a marked digestive action, but when mixed with hydrochloric acid its proteolytic power, like that of the alcohol precipitate, is immediately checked.

Experiment VIII.—Aqueous, dialyzed solution of the above described ammonium sulphate precipitate. The amount of dry albumin equivalent to the 10 grams of moist coagulum used in the digestions was 1·5120 grams. The mixtures were warmed at 40° C. for 5 hours.

	Ferment solution	Reaction	Undissolved albumin	Per cent digested
A	100^{cc} + 100^{cc} H_2O	neutral	1·1791 grams	22·1
B	100 + 100 0·2 % HCl	0·1 % HCl	1·4897	1·5

As previously stated, pineapple juice, and the isolated ferment as as well, manifests its proteolytic action in an alkaline-reacting fluid, as well as in the presence of an acid or neutral reaction. When, however, the solution becomes strongly alkaline proteolytic action is quickly retarded, the ferment in this respect differing very decidedly from the related ferments papaïn and trypsin. Thus, the addition of small quantities of sodium carbonate to neutralized pineapple juice, a few hundredths of one per cent., produces no noticeable effect, but as the quantity is increased the retarding action of the alkali becomes more pronounced, until at last it checks the proteolytic action of the ferment altogether. This is clearly shown in the following experiments:

Experiment IX.—The acidity of the pineapple juice employed was equal to 0·462 per cent. HCl. Necessary to neutralize 100^{cc} of juice, 13·4^{cc} of 5·0 per cent. solution of Na_2CO_3. The 10 grams of moist albumin coagulum used in the digestions contained 1·3516 grams of dry albumin. The mixtures were warmed at 40° C. for 1½ hours.

	Pineapple juice	Reaction	Undissolved albumin	Per cent digested
A	100^{cc}	¾ neutralized	0·9663 gram	28·6
B	100	neutralized	0·9465	30·0
C	100	0·025 % Na_2CO_3	0·9522	29·6
D	100	0·05 "	0·9735	28·0
E	100	0·10 "	0·9968	26·3

Experiment X.—The acidity of the pineapple juice employed was equal to 0·656 per cent HCl. Necessary to neutralize 100^{cc}, 19·1^{cc} of 5·0 per cent. solution of Na_2CO_3. The amount of dry albumin equivalent to the 10 grams of moist coagulum used in the digestions was 1·3468 grams. The mixtures were warmed at 40° C for 2 hours.

	Pineapple juice	Reaction	Undissolved albumin	Per cent digested
A	100^{cc}	neutralized	1·0257 grams	23·9
B	100	0·1 % Na_2CO_3	1·0577	21·5
C	100	0·5 "	1·2263	9·0
D	100	1·0 "	1·3520	0

Hence, as is evident from the above experiments, the addition of sodium carbonate to neutralized pineapple juice to the extent of 0·5 per cent, almost completely stops the action of the ferment, while the presence of 1·0 per cent. of the alkali carbonate checks it altogether. Doubtless, the isolated ferment would show a still greater susceptibility to the action of dilute alkaline fluids.

From the foregoing, it is evident that digestion with bromelin, the ferment of pineapple juice, goes on most vigorously in neutral solutions, but that the presence of small amounts of acid, especially such as are contained in pineapple juice, and of sodium carbonate interfere with the proteolytic action only slightly; larger amounts, however, check the action of the ferment altogether.

It is further evident from the foregoing results that the proteolytic ferment of pineapple juice is an exceedingly vigorous ferment. We cannot say definitely how much pure ferment by weight is contained in 100^{cc} of filtered pineapple juice. There is no doubt that the amount varies greatly in different specimens of fruit; in fact, our results show plainly differences in proteolytic power hard to be accounted for in any other way. Experiments to be described

later show that the proteolytic ferment is either precipitable by heat, or else is associated with proteid bodies so precipitated. Now since the total amount of matter precipitable by boiling from 100^{cc} of filtered pineapple juice amounts to only 27 milligrams, and this obviously cannot be all proteolytic ferment, it is probable that the amount of pure ferment contained in the quantity of pineapple juice used in the various digestions recorded does not amount to more than a few milligrams, and yet in one experiment with the above quantity of ferment the equivalent of 1714 milligrams of dry muscle proteids were dissolved in one hour at 40° C., and of blood fibrin an amount equivalent to 1283 milligrams of dry proteid in two hours at 40° C.

With such vigorous digestive action as this, many possibilities suggest themselves in the way of practical application of the isolated ferment, or even of the pineapple juice itself. As a means of peptonizing foods it offers peculiar advantages in that the products of digestion, to be referred to later, are free from the objectionable taste usually associated with peptones resulting from the proteolytic action of animal ferments. Again, the ferment cannot but constitute a good solvent for pseudo-membranes, while its vegetable origin would perhaps recommend it as a more agreeable remedy than the kindred ferments from animal tissue. In some sections, popular opinion has already accredited to pineapple juice virtue as a solvent for the false membranes formed in diphtheria, a belief which is now seen to be founded on a reliable basis.

2.—*Influence of temperature.*

It is a matter of common observation that the digestive ferments, or enzymes, present in the animal organism act most energetically at approximately the body temperature, viz: 38°–40° C. Certain of the vegetable ferments on the other hand, notably the diastase of malt, act most vigorously at a higher temperature. With papain, the proteolytic ferment of papaw juice, Martin demonstrated the greater activity of the ferment at temperatures between 30° and 36° C. than between 18° and 20° C. in neutral solutions,* but apparently the effect of higher temperatures was not tried.

Experiment XI.—The 10 grams of moist albumin coagulum used in the digestions contained 1·4990 grams of dry albumin. The several mixtures were warmed with the albumin at the stated tem-

* Journal of Physiology, vol. v, p. 221.

peratures for 2¼ hours, the juice having been first brought to the desired temperature prior to the addition of the albumin.

	Neutralized pineapple juice	Temperature	Undissolved albumin	Per cent digested
A	100 c. c.	12° C	1·3090 grams	12·7
B	100	20	1·3087	13·1
C	100	40	1·2281	18·1
D	100	49	1·1959	20·3
E	100	56	1·1709	21·9

Although in this experiment, the proteolytic action of the juice, for some reason, was not as great as usual the results show in a general way that the activity of the ferment increases with the rise in temperature up to 56° C. Further, that the ferment is active at comparatively low temperatures, although there is a striking difference (nearly 50 per cent.) in activity between the two extremes, viz: at 12° and 56° C. That this peculiar ferment is truly more active at 50°–60° C than at 30°–40° C., under the above conditions, is confirmed by the two following experiments:

Experiment XII.—The weight of dry albumin equivalent to the 10 grams of moist coagulum used in each digestion was 1·2937 grams. The several portions of neutralized pineapple juice were brought to the required temperatures in carefully regulated water-baths, and when the desired point was reached *the albumin was at once added* and the mixtures kept at the stated temperatures for two hours, after which, as in the other experiments, the undissolved albumin was filtered off, washed, dried and weighed.

	Neutralized pineapple juice	Temperature	Undissolved albumin.	Per cent digested.
A	100 c. c.	40° C.	1·0259 grams	20·7
B	100	49	0·9648	25·5
C	100	58	0·9337	27·8
D	100	66	0·9721	24·9

Experiment XIII.—This experiment was conducted in essentially the same manner as the preceding, but at different temperatures. The weight of dry albumin equivalent to the 10 grams of moist coagulum used in the individual digestions was 1·3710 grams. The ferment was allowed to act on the albumin for two hours at the respective temperatures. In this experiment, duplicate digestions were made and the results are interesting as showing about how much variation may be expected from the errors naturally incidental to methods of this character.

	Neutralized pineapple juice.	Temperature	Undissolved albumin	Per cent. digested
A	100 c. c.	50° C.	0·9190 gram	33·0
B	100	60	0·9289	32·3
C	100	60	0·9286	32·3
D	100	70	1·0669	22·2
E	100	70	1·0562	23·0
F	100	80	1·3665	0·4

From these two experiments it is plain that the ferment as contained in *neutralized* pineapple juice is most active, on coagulated egg-albumin at least, between the temperatures of 50° and 60° C. and, further, that even at 70° C. the ferment is decidedly active. At 80° C. there is practically no action whatever. In this connection it is to be remembered that neutralized pineapple juice when subjected to heat precipitation grows slightly turbid at 72°–74° C., with separation of a flocky precipitate at about 82° C. Doubtless the destruction of the ferment by heat above 70° C. is associated with this precipitation, it being quite possible that it is the destroyed ferment itself which is so precipitated.

When pineapple juice of *natural acidity* is warmed with egg-albumin at the above high temperatures, a result quite different from the preceding is obtained; under such conditions, the proteolytic action of the ferment is diminished rather than increased and at 70° C. or under, the ferment is completely destroyed. This is shown in the following experiment.

Experiment XIV.—The pineapple juice employed had an acidity equal to 0·454 per cent. HCl. The 10 grams of moist coagulum used in the digestions contained 1·2956 grams of dry albumin. The mixtures of pineapple juice and albumin were warmed at the given temperatures for two hours, 100 c. c. of pineapple juice being used in each digestion.

Temperature	Reaction.	Undissolved albumin.	Per cent. digested.
40° C.	natural acidity*	0·9667 gram	25·4
40	neutral	0·9679	25·3
55	natural acidity	1·0672	17·7
55	neutral	0·8968	30·8
70	natural acidity	1·3012	0
70	neutral	1;0581	18·4

From these results it is seen that while the neutralized fluid is more active at 55° C. than at 40° C., thus confirming the previous

* In this individual experiment, the neutralized and acid fluids, for some reason, show exactly the same digestive power at 40° C.

data, the acid-reacting fluid, on the other hand, shows far less digestive power at 55° C. than at 40° C. and further, at 70° C. is entirely devoid of digestive action, while the neutral fluid at the latter temperature is strongly proteolytic. The general trend of these results, therefore, is to show that the ferment in a neutral solution will withstand exposure to high temperatures better than in an acid-reacting fluid ; and further, that while the ferment in a neutral solution, as in neutralized pineapple juice, acts most energetically between 50° and 60° C., in an acid solution proteolytic action is most vigorous in the neighborhood of 40° C.

With pepsin, Biernacke* has shown that an acid solution increases the resistance of the enzyme to the destructive action of a high temperature ; thus this ferment in the presence of 0·2 per cent. hydrochloric acid may be heated up to 60° C. before it is killed, while in a neutral solution of the same strength the ferment is destroyed at 55° C. Trypsin, on the other hand, was found more resistant to heat in an alkaline fluid than in a neutral or weakly acid solution.

In this connection it is interesting to notice that the acid-reacting pineapple juice (natural acidity) subjected to heat precipitation grows turbid at 60°–62°, with separation of flocks at about 75° C.; in other words, the destruction of the ferment by heat in the acid-reacting fluid is coincident with the commencement of the precipitation, the same as in the neutralized juice.

While *neutralized* pineapple juice is extremely active on proteid matter at the high temperatures stated, exposure of the ferment solution by itself *in the absence of any proteid matter*, to the above temperatures for even a short time quickly destroys the ferment. This fact is clearly shown in the following experiment :

Experiment XV.—Given volumes of neutralized pineapple juice were placed in water-baths having the desired temperatures, and when the solutions themselves had reached the temperatures stated in the following table they were kept at that point for fifteen minutes, after which they were removed from the baths, cooled to 40° C. and 10 grams of coagulated egg-albumin added. The mixtures were then warmed at 40° C. for two hours and the proteolytic action determined in the usual manner. The amount of dry albumin (at 110° C.) equivalent to the 10 grams of moist coagulum used in the individual digestions was 1·3364 grams.

* Das Verhalten der Verdauungsenzyme bei Temperaturerhöhungen. Zeitschrift für Biologie, Band xxviii, p. 49.

	Neutralized pineapple juice	Warmed for 15 minutes at	Undissolved albumin	Per cent. digested
A	100 c. c.	40 C.	1·1060 grams	17·3
B	100	60	1·2049	9·9
C	100	70	1·2971	3·0
D	100	80	1·3420	0

While neutralized pineapple juice is capable of digesting more proteid matter at 60° C. than under like conditions at 40° C., warming the ferment solution alone at 60° for fifteen minutes, prior to the introduction of the albumin, diminishes the proteolytic power of the ferment full 50 per cent. This result suggests that the products of digestion protect the ferment, to a certain extent, from the destructive action of the high temperature. The ferment acts quickly on proteid matter, so that even after a few minutes exposure of a mixture of albumin and pineapple juice to 40°–70° C., some proteoses and peptone are doubtless formed, which can in some manner exert their protective action. When, however, the neutralized juice alone is heated to 60° C., in the absence of proteoses and peptone, the ferment is rapidly destroyed. Doubtless, the ferment as contained in pineapple juice is more resistant to heat, than a solution of the isolated ferment would be, from the possible protective action of salts present, although of this point we cannot speak definitely. These results accord with Biernacki's* observations on the ferments pepsin, trypsin and ptyalin. This investigator found that albumose, amphopeptone and antipeptone raised the temperature at which trypsin was destroyed five degrees or more; that peptone raised the temperature at which pepsin was destroyed in acid solution, from 50°–55° C. up to 70° C. These results may perhaps be explained on the ground of a combination of the ferments with the albuminous bodies, the hypothetical compounds having greater resistance towards heat than the ferment alone. In any event, the general statement may be made that the purer the ferment the less resistant will it probably be to the destructive action of high temperatures.

While the preceding results show that the pineapple ferment, as contained in filtered pineapple juice, is liable to be killed on long-continued exposure to temperatures favorable for its proteolytic action, the fluid may be heated at temperatures under 40° C. for long periods of time, or even evaporated to dryness, without destruction of the ferment, provided the temperature is carefully regulated and

* Zeitschrift für Biologie, Band xxviii, p. 49.

not allowed to pass beyond 40° C. This is demonstrated by the following experiment:

Experiment XVI.—The pineapple juice employed had an acidity equal to 0·445 per cent. HCl, 100 c. c. requiring 13 0 c. c. of a 5·0 per cent. solution of sodium carbonate for neutralization. The 10 grams of albumin coagulum used in the digestions contained 1·3633 grams of dry albumin.

A	100 c. c. pineapple	juice	+ 13·0 c. c. 5 per cent.	Na_2CO_3 sol.
B	100 "	"	+ 13·0 " "	" "
C	100 "	"	+ 13·0 "	H_2O
D	100 "	"	+ 13·0 "	"

Solutions B and D were evaporated to dryness on plates at 40° C., the residues dissolved in water and made up to 113 c. c. respectively. All four solutions were then mixed with 10 grams of albumin coagulum and warmed at 40° C. for 3½ hours, after which the amount of albumin digested was determined in the usual manner.

	Reaction etc.	Undissolved albumin	Per cent digested.
A	neutral	0·8177 gram	40·1
B	" evaporated	1·0215	25·1
C	natural acidity	0·8932	34 5
D	" evaporated	0·8638	36·7

From these results, it is plain that pineapple juice of natural acidity can be evaporated to dryness at a temperature not exceeding 40° C. and still preserve its proteolytic power. With neutralized juice, however, the above results indicate a partial destruction of the ferment during the evaporation. Whether this is due to the action of the neutral salts formed by neutralization of the acid, or to some other cause we cannot say. Possibly, the solution may have been made slightly alkaline, which would naturally give rise to some destruction of the ferment. Several repetitions of the above experiment, less carefully conducted, have shown that evaporation of the acid juice, however, is very liable to result in a partial loss of proteolytic power, unless great care is taken in keeping the evaporating fluid at 40° C. or under.

3.—*Rate of action.*

Pineapple juice is not only exceedingly active on proteid matter, but under favorable circumstances the digestive power of the ferment is quickly manifested. On blood fibrin and muscle tissue, especially, the proteolytic action of the ferment is shown in a *rapid*

solution of the proteid substance; in fact, a single observation of the manner in which blood fibrin is attacked by pineapple juice is sufficient to give one a just appreciation of the energy of the ferment. Thus in Experiment IV, it will be remembered that 50 per cent. of the blood fibrin used in the experiment was converted into soluble products in two hours, and that in Experiment V, with the proteids of muscle tissue, 58 per cent. of the proteid matter was dissolved by neutral pineapple juice in half an hour at 40° C. Naturally, on coagulated egg-albumin the digestive power of the ferment is less quickly manifested, but the experiments already recorded show that even with this more difficultly digestible proteid, the rate of action is fairly rapid. The two experiments following give a general impression of the rate of action of the ferment, in the digestion of coagulated egg-albumin.

Experiment XVII.—The 10 grams of albumin coagulum used in the digestions contained 1·3944 grams of dry albumin. The mixtures were warmed at 45° C. for the periods stated in the following table, the amount of albumin digested during the periods being then determined in the usual manner.

	Neutralized pineapple juice	Time	Undissolved albumin	Per cent digested
A	100 c. c.	½ hour	1·3026 grams	6·6
B	100	1	1·2072	13·5
C	100	2	1·0827	22·4
D	100	4	0·8814	36 8
E	100	5	0·8521	38·9

Experiment XVIII.—The 10 grams of albumin coagulum used in the digestions contained 1·4333 grams of dry albumin. The mixtures were warmed at 40° C. for the different periods stated, after which the undissolved albumin was filtered off, washed and weighed.

	Neutralized pineapple juice	Time	Undissolved albumin	Per cent digested
A	100 c. c.	¼ hour	1·3201 grams	7·9
B	100	½	1 2472	13·0
C	100	1	1·1554	19 4
D	100	2	1·1366	20·7
E	100	4	1·0117	29 5
F	100	6	1·0012	30·2

While the results of these two experiments differ somewhat from each other in some respects, they are alike in showing that the ferment commences to act upon the proteid matter at once, and that this digestive action steadily continues, in the case of the above proteid, for about four hours, after which time the action becomes very much slower.

Separation of the proteolytic ferment.

Saturation of neutralized pineapple juice with ammonium sulphate precipitates, as already stated, all of the proteid matter contained in the solution. The filtrate does not give the slightest trace of a turbidity on boiling, even after the addition of acetic acid. Nitric acid likewise fails to give any reaction. Acetic acid and potassium ferrocyanide, however, give a slight flocky precipitate, which does not appear to be composed of proteid matter. The ammonium sulphate precipitate contains all of the proteolytic ferment and likewise the milk-curdling ferment, if this is a distinct body. It is readily and completely soluble in water, and by long continued dialysis the solution can be freed from ammonium sulphate. Unless every trace of adherent salt is removed from the solution, the fluid remains fairly clear, but the reaction so far as our experience extends becomes, almost invariably, slightly alkaline. On evaporation of the fluid, after removal of all, or nearly all of the salt, a scaly residue is obtained readily soluble in water, or in the slight trace of salt present, with strong proteolytic power and giving distinct reactions with the xanthoprotein, biuret and Millon's test. The aqueous solution is usually slightly turbid, the turbidity however disappearing on the addition of a little salt-solution, especially with the aid of a gentle heat, also on the addition of 0·2 per cent. hydrochloric acid. Evidently, the bodies composing the ammonium sulphate precipitate are readily soluble in very dilute salt-solution, if not in water alone.

This method constitutes a fairly good way of separating the ferments from the bulk of the extraneous matters present in the juice. We have not, however, spent much time in a close study of the make-up of this product as it is obviously a mixture of essentially all the proteid bodies contained in the juice, but it makes a very good preparation with which to demonstrate the proteolytic and milk-curdling properties of the ferments.

The most satisfactory method we have thus far found for the isolation of the proteolytic ferment, and one which yields a product with very strong digestive power, is by precipitation with common salt.

Saturation of neutralized pineapple juice with sodium chloride gives rise to a small flocculent precipitate, which is not at all increased by the addition of acetic acid to the salt-saturated fluid. Obviously, this precipitate might be composed of a globulin, or of a body akin to heteroproteose. It was studied after the following

plan: a large volume of freshly filtered juice was carefully neutralized with sodium carbonate, and then saturated at the temperature of the room with pure salt. The slight flocculent precipitate which resulted was filtered off, washed with saturated salt-solution, then dissolved in water and dialyzed in running water, putrefaction being prevented by addition of thymol. After several days' dialysis, though still containing some sodium chloride, a portion was tested as follows: it had the appearance of a somewhat turbid fluid, as though a separation had commenced to take place, but it could not be filtered clear. On warming the mixture gently, the turbidity showed a tendency to clear up somewhat. Subjected to careful heating, the mixture appeared to show an increased turbidity at 65° C., while at 72° C. there was a distinct and heavy turbity, but no separation of flocks. As the temperature was raised, the turbidity changed to a thick milkiness without, however, any appearance of flocks even on boiling. The solution seemed perfectly neutral to delicate test papers. By judicious addition of dilute acetic acid and renewed heating, the milky fluid was finally made to yield a flocky precipitate, in the filtrate from which no proteid reaction could be obtained, thus indicating that the sodium chloride precipitate is composed wholly of matter precipitable by heat.

The solution taken from the dialyzer showed strong proteolytic action on blood fibrin.

The remainder of the solution was dialyzed for one week longer, until nearly every trace of sodium chloride was removed, and again tested. The fluid had a very milky appearance, but no distinct separation of flocculent matter was seen. This heavy turbidity cleared up somewhat on warming and disappeared completely on adding a few drops of 20 per cent. salt-solution, also on the addition of a drop or two of dilute nitric acid. The addition of more nitric acid to the latter solution was followed by the reappearance of a turbidity, which did not disappear by gentle heat, but separated into flocks, not readily soluble in a large excess of nitric acid.

The reaction of the solution taken from the dialyzer was faintly alkaline. Heated, the solution became distinctly turbid at 65°–70° C. and quite opaque at 80° C., but without separation of flocks until after persistent boiling. A drop of acetic acid, however, added to the boiling fluid quickly caused a flocculent precipitate, the filtrate from which was practically free from all trace of proteids. The salt-free solution, although faintly alkaline, still showed strong proteolytic power.

On cautiously adding 0·2 per cent hydrochloric acid to the faintly alkaline fluid a heavy turbidity made its appearance, which changed to a flocculent precipitate as the fluid became slightly acid; on addition of a small excess of acid the precipitate quickly dissolved. From this it may be inferred that if the solution had been perfectly neutral, a more pronounced separation of the proteid might have occurred in the dialyzer tube; evidently, however, the body is extremely soluble in very dilute acid and alkaline solutions, as well as in dilute solutions of neutral salts. Thus, the precipitate produced in this manner by the addition of a little 0·2 per cent. hydrochloric acid was readily dissolved by 10 per cent. salt-solution, the fluid becoming turbid again on boiling, with separation of a flocculent precipitate.

Further, by gently warming the turbid mixture resulting from the addition of a few drops of 0·2 per cent. hydrochloric acid, the fluid cleared up almostly completely, the turbidity returning as the mixture cooled.

Addition of dilute hydrochloric acid, however, did not precipitate all of the proteid; the filtrate still contained some proteid matter and, moreover, showed marked proteolytic action on fibrin. Thus in one instance, 0·2 per cent hydrochloric acid was added to the dialyzed solution until a distinct flocky precipitate resulted, this was filtered off and dissolved in 10-per cent. solution of sodium chloride. This solution on being heated gradually, grew turbid at 66°–68° C. but did not yield any further precipitate even on boiling. The turbidity did not disappear on the addition of 0·5 per cent sodium carbonate, or of 0·2 per cent. hydrochloric acid, but was soluble in dilute potassium hydroxide.

The filtrate from the above precipitate showed marked proteolytic action; it also yielded a slight precipitate with strong nitric acid, not dissolved by warming; subjected to heat precipitation the solution grew turbid at 73° C., but did not give any further precipitate even on boiling. The turbidity did not readily disappear on the addition of either dilute hydrochloric acid or of 0·5 per cent. sodium carbonate, but was quickly soluble in very dilute potassium hydroxide. Evidently, the substance precipitated by the acid and that remaining in solution were essentially the same.

From the foregoing, it is plain that the proteid substance precipitated by saturation of neutral pineapple juice with sodium chloride, is a peculiar body partaking both of the characters of a globulin and of heteroproteose. That it approximates more closely to the latter

is evident from the fact that the several precipitates produced by heat are more soluble in dilute alkalies than is customary for coagulated globulin, and that the precipitate produced by addition of dilute hydrochloric acid is so readily soluble on warming the neutral or slightly acid mixture, followed by its re-appearance as the temperature is lowered. On the other hand, the pronounced insolubility of the proteid in warm nitric acid of all strengths is contrary to the usual behavior of the proteoses. Further, the substance gives a biuret reaction more violet than red, and when boiled for a short time with 0·5 per cent. sodium carbonate it is transformed apparently into alkali-albumin, since the precipitate resulting from neutralization of the alkaline fluid is then insoluble in salt solution, although readily dissolved by a slight excess of dilute hydrochloric acid.

It is further evident that the proteolytic ferment of pineapple juice is either associated with this peculiar globulin or proteose-like body, or else is the body itself. The above method of precipitating the proteolytic ferment, by saturation of the juice with sodium chloride, brings about a complete separation of the ferment, provided the fluid is fully saturated with the salt. The filtrate, however, still contains some proteid matter, precipitable by shaking the fluid with neutral ammonium sulphate. This substance was separated from a large quantity of juice, by treating the filtrate from the sodium chloride precipitate with ammonium sulphate, added to complete saturation.

The slight stringy precipitate which resulted was filtered off, dissolved in water and dialyzed. After several days a small portion of the solution, though still containing some salts, was tested as follows: heated gradually the solution became slightly turbid at 65°–70° C., with separation of flocks at 80°–82° C. The filtrate from this precipitate gave no further signs of separation even when heated to boiling, but a drop of acetic acid added to the hot fluid produced a slight turbidity.

The dialysis was continued for about ten days longer, until the salts were almost wholly removed, when the solution was found faintly alkaline and slightly turbid. This turbidity disappeared at once on addition of a drop of dilute nitric acid, also on the addition of a few drops of salt solution. Addition of 0·2 per cent. hydrochloric acid to faint acid reaction produced a slight precipitate, readily soluble in salt solution. Subjected to heat precipitation, the turbid fluid cleared up somewhat at first, then became slightly turbid

at about 68° C., the turbidity becoming more pronounced at 75°–80° C., followed by the separation of a fine flocculent precipitate at 85°–87° C. A more complete separation was obtained by adding a drop of acetic acid to the hot fluid. The precipitate produced by heat at about 85° C. was almost wholly insoluble in dilute alkalies.

This ammonium sulphate precipitate was found wholly free from any proteolytic power either in neutral, acid or alkaline solutions. With the biuret test it gave a very faint violet color.

Hence, as already stated, saturation of neutral pineapple juice with sodium chloride precipitates all of the proteolytic ferment present, while there remains in solution some proteid substance, precipitable by ammonium sulphate, having essentially the same chemical properties as the preceding body. Certain points of difference, however, are noticeable; thus the body precipitated by sodium chloride shows more of a tendency to separate from its solution on dialysis, than the substance precipitated by ammonium sulphate. Further, the former body on exposure to heat precipitation separates less readily from its solution, except on the addition of a drop of acid, although the solution shows a heavy turbidity at much the same temperature as the latter body. The one thing, however, to be emphasized here is that the sodium chloride precipitate is strongly proteolytic, while the body separated by ammonium sulphate is devoid of this property. A more exact study of the chemical status of these two substances is now in progress, but at present nothing more definite can be said.

Another method of separating the proteolytic ferment is by precipitation with magnesium sulphate. Saturation of neutralized pineapple juice with this salt gives much the same separation as that produced by saturation with sodium chloride; i. e. a slight flocky precipitate, readily soluble in water and, after removal of the adherent salt, strongly proteolytic. The filtrate still contains some proteid matter, precipitable in small quantity by the addition of sodium sulphate in substance.

The magnesium sulphate precipitate was examined with the following results; it was dissolved in water and dialyzed for several days, until the greater portion of the adherent salt was removed. On testing the solution by heat precipitation, it grew distinctly turbid at 62° C., with separation of flocks at 75° C. This precipitate represented practically all of the proteid present in the solution, for boiling the filtrate, with or without acid, failed to give any further separation other than a faint turbidity produced by the

acetic acid. The dialysis was continued for a week or more longer, until every trace of sulphate was removed, when the reaction of the solution was found distinctly alkaline, so much so that no precipitate separated even on boiling the solution, although it became quite opaque at about 78° C., until a drop of acetic acid was added In another preparation, where the alkalinity was less pronounced, the solution after dialysis of all, or nearly all of the salt, gave a flocculent precipitate at 85° C.

The faintly alkaline solution of the proteid yielded a precipitate on addition of 0·2 per cent. hydrochloric acid, very soluble in a little salt solution and in a slight excess of 0·2 per cent. acid. Only a portion of the substance was separated however, by this method of precipitation The filtrate, which appeared nearly neutral to test papers, on being heated grew turbid at 73° C., without however any separation of flocks until the solution was boiled. The slight flocculent precipitate which then resulted was wholly soluble in 0·5 per cent. sodium carbonate, and nearly so in 0·2 per cent. hydrochloric acid. Further, the filtrate had marked proteolytic power and treated with nitric acid gave a distinct turbidity, not appreciably diminished by warming the mixture. That portion of the proteid precipitated by the dilute hydrochloric acid gave, after solution in dilute sodium chloride, essentially the same reactions as the foregoing, so that evidently the two fractions were identical.

This preparation of the ferment agreed fairly well in its reactions with the substance separated by sodium chloride. Like the latter, the turbid solution resulting from the dialysis cleared up on addition of a little salt solution, likewise on the addition of a few drops of dilute nitric acid, while more acid produced a second turbidity not readily dissolved by an excess of the acid, or by heat. With the biuret test, a more distinctly reddish color was produced than heretofore seen.

There are, therefore, two good methods for the isolation of the proteolytic ferment from pineapple juice ; one by saturation of the neutralized fluid with sodium chloride, the other by saturation with magnesium sulphate. In our opinion, the former method yields a product with the strongest proteolytic power, although this needs to be verified by further observations. As to the exact chemical nature of the ferment, or of the body it is associated with, we are not yet able to speak with perfect confidence. It is our opinion that the proteolytic body separated by the above methods is a mixture of a globulin and a proteose, but as yet we have not been able to accomplish a dis-

tinct separation. On the other hand, it is possible that the substance is a single body possessed of properties akin to both the above, but this view seems hardly probable; its precipitation by saturation with magnesium sulphate and by sodium chloride possibly favor its being a globulin, while its extreme solubility in dilute salt solutions, in dilute acids and alkali are equally characteristic of both bodies. The more or less constant solubility of the heat precipitates in dilute alkalies favors its proteose nature, and if a proteose it is most closely related to heteroproteose. The substances are, moreover, alkaline reacting bodies completely precipitable by heat, especially in the presence of a trace of acid.

We are now occupied, with the aid of larger quantities of material, in an attempt at a better separation of these bodies with the hope of acquiring more definite knowledge regarding their chemical nature, composition, etc.

Whether globulin or proteose, these bodies present in pineapple juice, are very resistant to the digestive action of the ferment. Thus, long continued warming (3–5 hours) of fresh pineapple juice with strong proteolytic power at 40° C. does not, in the least, change the temperature at which the several heat precipitations occur; a point which certainly indicates the resistance of these proteids to proteolytic, or at least to this particular kind of proteolytic, action, the bodies in this respect resembling the *atmid* bodies described by Neumeister.*

Products formed by the proteolytic action of the ferment.

On this point, we have made only a few preliminary experiments, designed simply to throw some light on the nature of the ferment as a proteolytic agent. The results indicate that the ferment is more nearly related to trypsin than to pepsin, in that not only are proteoses and peptone formed by its action, but also leucin and tyrosin.

When washed and boiled blood fibrin, for example, is warmed at 40° C. with fresh pineapple juice of *natural acidity* for two or three hours, the proteid matter is thoroughly digested, but, as previously stated, a fairly large residue of finely divided matter remains undissolved, resistant to the further action of the ferment. This antialbumid-like matter is readily soluble in weak solutions of sodium carbonate, from which it is re-precipitated by addition of acetic acid,

* Zeitschrift für Biologie, Band xxvi, p 57. "Ueber die nächste Einwirkung gespannter Wasserdämpfe auf Proteine und uber eine Gruppe eigenthümlicher Erweisskörper und Albumosen."

and not readily dissolved by an excess of the acid. This same body is likewise formed by the action of fresh pineapple juice in neutral or weak alkaline solutions, and also by the isolated ferment as prepared by the methods previously described.

Boiling the acid digestive fluid gives no noticeable coagulum, and addition of moderately strong nitric acid likewise fails to produce any precipitate. Neutralization of the acid digestive mixture may give rise to a small amount of a neutralization precipitate, resembling acid-albumin. On evaporation of the neutralized fluid, the solution remains fairly clear, and when sufficiently concentrated addition of strong alcohol gives a gummy precipitate of proteose and peptone, while from the alcoholic solution crystals of tyrosin can be obtained and, in lesser quantity, leucin also. Tyrosin appears to be present in much larger amount than leucin. On dissolving the alcohol precipitate in water and saturating the solution with ammonium sulphate a heavy precipitate of proteose is obtained, while in the filtrate a large amount of true peptone is found, which after removal of the sulphate by dialysis gives a bright red color with the biuret test, etc. So far as our experiments extend, the proteose is composed mainly of a deutero-like body, only a small precipitate being obtained by saturation with sodium chloride, either in a neutral or slightly acid solution. An experiment like the preceding carried out with coagulated egg-albumin gave essentially the same results.

When pineapple juice of *neutral or faintly alkaline reaction*, or a *neutral or slightly alkaline solution* of the proteolytic ferment, is warmed with blood fibrin, for example, the digestion appears much the same as the preceding, but on heating the filtered solution a very pronounced milky turbidity appears, which on addition of a drop or two of acetic acid changes to a heavy flocculent precipitate, insoluble in excess of the acid.

Further, addition of nitric acid to the neutral or slightly alkaline digestive fluid gives a heavy curdy white precipitate, insoluble on application of heat, and likewise insoluble in an excess of the acid. Heated with an excess of acid, the precipitate takes on an intense yellow color. This precipitate produced by nitric acid is likewise insoluble in a 10-per cent. solution of sodium chloride, at least in the presence of the acid.

This body, so characteristic of bromelin digestion in *neutral or faintly alkaline* solutions, is very resistant to the action of the ferment, being still present even after a long-continued digestion. It seems probable that this substance results from the action of the fer-

ment in a neutral or alkaline solution, on the insoluble antialbumid-like body so conspicuous in an acid digestion; for while the latter body is also present in neutral and alkaline digestions, the amount seems smaller, and further, the reactions of the two bodies are very much alike.

Aside from this one point of difference, the products formed in a neutral or alkaline digestion are, so far as we have seen, essentially the same as those formed by pineapple juice of natural acidity. Thus, on boiling a slightly alkaline digestive mixture resulting from the action of the isolated ferment on blood fibrin, and adding a drop or two of acetic acid to facilitate the separation of the coagulum, a clear filtrate was obtained, without trace of reaction with nitric acid, except in the presence of salt, and giving the usual reactions for proteose and peptone. Thus, the addition of concentrated salt-solution to the clear filtrate, followed by a few drops of acid gave more or less of a turbidity, readily dissolved on application of heat, reappearing on cooling.

We hope soon to present a more detailed report regarding the properties and composition of the several products resulting from the action of the isolated ferment on egg-albumin, blood fibrin and myosin.

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XVIII.—The Nephrostomes of Rana. By Oliver C. Farrington.

In the Urodela, as is well known, nephrostomes are always present, serving as a means of free communication between the body cavity and uriniferous tubules. According to Hoffman,* both Spengel and Meyer, whose elaborate investigations independently made, first gave us accurate knowledge of the structure and office of the nephrostomes of Urodela, state that these organs exist also in the Anura, but they were unable to determine with certainty the point of connection between them and the tubules. The nephrostomes appear, according to these authors, on the ventral surface of the kidney, where this is covered by the peritoneum. Their number varies in different genera, but in Rana there are from 200 to 250. In most genera they open directly inward, but in some they take a short horizontal course on the surface before entering the kidney. As before stated, their point of junction with the tubule is difficult to establish with certainty, but according to the view of Spengel they unite with the fourth section of the tubule rather than with the first section or neck as in Urodela. Nussbaum also investigated this question and his first results† confirmed Spengel's views. Later investigations,‡ however, led him to the belief that although during the tadpole stage the nephrostomes connect with the neck of the tubule, as development proceeds they are forced away from it and open, in the adult frog, into the branches of the renal-portal vein. Haslam,§ the most recent writer on the subject, controverts all the previous views, stating that neither in microscopic sections or teased preparations has he been able to find any trace of such organs. The conclusions which he draws from various experiments on the frog are as follows: "If the peritoneal funnels exist in the adult frog, (1) they are very difficult to find; (2) they do not form a free communicating path between any part of the uriniferous tubules and the abdominal cavity; (3) their superficial terminations have no free cilia." Heidenhain, according to this author, was also unable to find these organs.

* Bronn's Klassen und Ordnungen des Thier-reichs, vol. vi, p. 461.

† Sitzungsb d. Niederrheinischen Gesell. in Bonn, 1877, p. 122

‡ Zool. Anzeiger, 1880, No. 67, p. 514.

§ Ecker's Anatomy of the Frog. Translated by Geo. Haslam, 1889, p. 336.

The subject is one of interest, since it is desirable that we should know at what point in the ascending scale of animal life these organs, which probably exist in all vertebrates as an embryonic feature, cease to characterize the adult forms.

In the hope that the recent improved methods of section cutting and reconstruction might throw additional light on the question, the work which is described in the following pages has been done by the writer.

In carrying on this work, all the experiments which were made on the frog were duplicated by similar ones on the newt, and the same is true of all the preparations made for section cutting. This was done in order to compare directly results obtained in a species where the nephrostomes are known to exist, with those given by the frog.

Two species of Rana were used, *Rana Catesbiana* and *Rana virescens*, but no dissimilar results due to difference of species were noted. Of the newt, the species used was the common *Diemyctylus virescens*.

The investigation has led to the following conclusions:

I. Microscopic sections of the frog's kidney often show, passing inward from the ventral surface, small tubes which are to be regarded as nephrostomes.

II. These tubes have free, active cilia.

III. Strong, if not conclusive evidence exists to show that these open into the blood capillaries of the kidney.

I. Fig. 1 shows a section of the newt's kidney with nephrostomes appearing at various points indicated by the letter *n*.

At the surface these have a diameter of about $\cdot 04^{mm}$, then passing inward show a slight funnel-like enlargement to about $\cdot 06^{mm}$. For this part of its course the tube is seen to be made up of a ciliated epithelium, the cells of which are narrow, elongated, somewhat fusiform, and have indistinct nuclei. Two of these funnels are seen uniting in a common tube, in fig. 1, an arrangement stated by Spengel to be quite common. For the rest of its course the tube, having a diameter of about $\cdot 024^{mm}$, loses its distinctive epithelium and its walls are thin and structureless till it opens into the uriniferous tubule (*u. t.* fig. 1). Figs. 2, 3 and 4 show sections of the kidney of the frog prepared similarly to those of the newt. As will be seen, these show openings or cavities on the ventral surface, about $\cdot 035^{mm}$ in diameter, lined with a distinctive epithelium and resembling in every respect those just noted in the newt. The distance to which

they can be traced inward depends on the favorableness of the section. The one shown in fig. 3 extends inward for a distance of $\cdot 16^{mm}$. By tracing the openings onward through successive sections we find them passing into a tube of an average diameter of $\cdot 06^{mm}$, which continues its course near the ventral surface of the kidney (*n. t.* fig. 2). The tube finally loses its distinctive structure and opens probably into the capillaries flowing toward the vena cava inferior. This inner termination, however, it was found impossible to trace with certainty, though it was sought for with the greatest care through a large number of sections. The opening at the point of junction is undoubtedly extremely small, so that the chances of finding a section in which it could be traced with certainty would be few indeed. The nature of the epithelium lining the nephrostome is shown in fig. 3. It is seen to be made up of large cuboidal cells having well defined nuclei and resembling in size and shape the cells of the uriniferous tubules, though they lack the striations which usually characterize these. At the opening on the surface the cells become flattened and smaller and the cell outline is less distinct.

The nephrostomes of tadpoles were found to possess a similar epithelium, but in the tadpoles the cells are more nearly like those of the uriniferous tubules than in the adult frog.

The method of preparation of these kidneys and of those of the frog was to preserve in Müller's fluid 24 hrs., transfer to 95 per cent. alcohol and stain with hæmatoxylin.

II. The cilia appear so plainly in sections that there can be no doubt of their presence. Further evidence of ciliary action was obtained, however, by adoption of the method proposed by Nussbaum (l. c.), which he describes as follows: "Chloroform the animal until respiration has ceased. Inject in the body cavity 0·5 per cent. salt solution containing powdered carmine. Close the body wall. Immerse the animal for 3 hrs. in Muller's fluid and after 12–24 hrs. transfer the kidney to alcohol."

As Nussbaum states, thin sections of the kidney will then show the carmine distributed through the funnels and tubes, thus giving positive evidence that its fine particles have been carried inward by ciliary action. Such a section is shown in fig. 2. Haslam states (l. c.) that having placed properly dissected frogs in 0·6 per cent. sodium chloride solution in which finely divided gamboge was suspended, no trace of ciliary action was in any case found on either surface of the kidney.* In what way it was anticipated that the ciliary action would show itself is not stated, but it is doubtful if the cilia of

openings so minute could produce currents or accumulations of particles large enough to be seen from the surface. Applying the experiment of Nussbaum, however, at seven different times to both male and female frogs of various sizes, the evidences of ciliary action previously described were observed in every case.

III. Our belief that the nephrostomes in the frog open into the blood capillaries of the kidney, rests mainly on the fact that sections prepared after Nussbaum's method show that the carmine is present not only in the nephrostomes, but in the blood capillaries and large veins which are near the ventral surface of the kidney. This is shown in both figs. 2 and 4. Applying the method of Nussbaum to the newt, we find the carmine invariably in the uriniferous tubules and not in any other part of the kidney. In the frog, however, the carmine is not found in the tubules at all but only in the blood vessels. This makes the evidence almost conclusive that the nephrostomes open into the tubules in the one case and into the blood vessels in the other. We need, however, to trace the tube directly to its termination before we can assert positively its connection, since it may be possible that the carmine could make its way into the circulation by some other course. Nussbaum states that by sections cut in glycerine he was able to follow directly the course of the carmine from the nephrostome into the blood vessel. It is very doubtful, however, if the evidence from such sections could be relied upon, since the writer found that unless some fixative for the carmine was used the particles were scattered by the knife through every part of the kidney. To overcome this difficulty use was made of a method for imbedding proposed by Prof. S. I. Smith. The kidney was imbedded in celloidin, but instead of trying to make sections of this block by the usual method of cutting under alcohol, the block was reimbedded in paraffine. From this block, then, sections could be cut as usual with paraffine, and the celloidin held all particles so firmly in place that there could be no doubt that the place of the carmine in any part was that it had naturally reached. From fig. 4, which represents a section prepared after this method, it will be seen that the carmine appears only in those blood vessels near the ventral surface. This was invariably true, and hence the conclusion that the nephrostomes open into the capillaries flowing into the vena cava. This fact, moreover, makes it quite unlikely that the carmine could have entered the circulation in any other way than through the nephrostomes, for it would then be equally distributed through the blood vessels of the kidney. To test this point further, the vena cava inferior of a live frog was tied

just above the kidney before injection of the carmine. It was hoped thus to determine whether the carmine would enter the circulation through other vessels, if it were not supplied by the kidneys. Upon examination the particles were found to have entered the nephrostomes only a little way, and were not present in any of the blood vessels; but, as the stopping of the circulation caused the animal to die very quickly, the test was not regarded decisive.

It seems probable that if the nephrostomes connect with the blood vessels they would be reached by injections of the latter. As no mention is made by other writers of experiments of this kind, except that of the injection of the ureters by Haslam, this point was carefully tested. The first injection was made through the vena cava inferior, the anterior abdominal being also opened. This showed only the blood vessels to be injected and no passage of the fluid into any of the nephrostome tubes. The second injection was made in the same way except that the renal-portal of one side was tied so that if any extra pressure were needed to force the fluid into the tubes it might be thus supplied. The results were, however, like those of the first injection. The third injection was made through the renal-portal of a very large frog with the anterior abdominal opened. By this means the nephrostomes were successfully injected, the fluid showing plainly in the tubes and funnels and even coming to the surface, though it did not flow out to any extent. This result seems to place the connection of the nephrostomes with the blood vessels almost beyond question. On seeking, however, to trace the direct opening of the nephrostome tube into a blood vessel by means of sections, it was found as before impossible to do so with absolute certainty, though the connection was in many cases very close. Since the nephrostomes probably serve as lymph vessels, the openings into the capillaries must be small enough to prevent the passage of the blood corpuscles into them, so that, as before stated, the chances of tracing them with certainty are few indeed. The experiments seem to teach that the passages inward from the nephrostomes can be reached by a current going toward the vena cava but are closed to one coming from it. This is difficult to explain if true, but needs further proof. The remarkable change of function which the nephrostomes seem to undergo, from service as excretory organs to that of lymph vessels, gives rise, also, to physiological questions of much interest. It is not, however, the purpose of this paper to discuss these, since they call for much further investigation. It is the hope of the author that others may study these points and bring new facts to light.

A few points may be mentioned regarding the macroscopic appearance of the nephrostomes. The writer found they could be seen plainly from the surface by staining the kidney in 0·5 per cent. silver nitrate solution from 3 to 5 minutes. By this treatment the nephrostomes are made to appear like minute *craters* scattered over the surface. As noted by Hoffman, they are most abundant in the region medianward from the adrenal gland and are especially numerous near the large branches of the vena cava. Fig. 5 is an attempt to represent their distribution and appearance, though it is difficult to do this by a drawing. The nephrostomes are represented by dots and the little circles indicate lighter spots on the surface which are often mistaken for their openings but are in reality produced by the Malpighian capsules showing through. The largest number of nephrostome openings counted on any one kidney was 150.

In conclusion the writer wishes to acknowledge his indebtedness to Prof. S. I. Smith, at whose suggestion the investigation was undertaken and whose valuable advice and assistance have been freely rendered during the work.

Sheffield Biological Laboratory, June, 1891.

EXPLANATION OF PLATE XXIV.

Fig 1 Dorso-ventral section of kidney of *Diemyctylus viresceus*. 9μ in thickness

Fig 2 Ventral portion of dorso-ventral section of kidney of *Rana Catesbiana*. 9μ in thickness.

Fig 3. Similar section showing single nephrostome. 6μ in thickness.

Fig. 4. Similar section entire, showing the distribution of the carmine in the blood vessels

Fig 5 Right kidney of *Rana Catesbiana*, female Ventral view.

a artery, *b v.* blood vessel, *c.* carmine; *M.* Malpighian capsule; *n.* nephrostome; *n t* nephrostome tube, *u t* uriniferous tubule; *v i.* large vein leading to vena cava The ventral surface in the figures is to the left, dorsal to the right. The carmine where not lettered is represented by black dots.

XIX.—Notes on the Fauna of the Island of Dominica, British West Indies, with Lists of the Species obtained and observed by G. E. and A. H. Verrill. By G. E. Verrill.

The following collections were obtained by my brother and myself during March, April, and May, 1890, on the Island of Dominica, one of the Lesser Antilles, situated in Lat. 15° 18′ to 15° 45′ N. and Long. 61° 14′ to 61° 30′ W.

This island lies approximately north and south, is of volcanic origin, rising abruptly from the sea, and is about 29 miles long by 17 wide, the whole containing about 290 square miles. Generally speaking it is composed of a high central ridge or crest running lengthwise, the crest itself being made up of a number of peaks, the highest attaining an altitude of about 5300 feet.

From this central crest it slopes down to the east and west in a succession of lower peaks and ridges with deep valleys and ravines between, many of which contain rapid mountain streams. Close to the coast these valleys widen, frequently to quite an extent, giving chance for sugar plantations, etc. This is particularly the case on the western, or leeward side, where the slope is much less than on the windward, or Atlantic side, so that it is possible to cultivate the ground well up on the mountains on the former side.

The vegetation of the island is of the most luxuriant type, covering the mountains to their tops and consisting of a very great variety of trees, palms, tree-ferns, shrubs, vines, etc. The tree-ferns are very abundant and often twenty feet or more high. Many of the trees reach a great height, while the smaller ones with the various vines and lianas form a network almost impassable unless a person is armed with a "cutlass" or "machete" almost invariably carried by the natives to cut their way.

The temperature along the coast averages about 85° F. most of the time, but back in the interior, among the mountains, it is much cooler; so cool, in fact, that at night one needs a pair of good heavy blankets. The climate is also very damp, especially up in the mountains where, even during the dryest portion of the year, there is a succession of short, sharp showers every day, each followed by

bright sunshine. In fact it not unfrequently rains from a cloudless sky, so that one is no sooner dry from one shower than he is pretty sure to be drenched by another.

This island appears to have been but very little visited by collectors. So far as I am aware but one collection of any size, that of Mr. Fred. A. Ober, made in 1877 for the Smithsonian Institution, has previously been sent to this country (cf. Proc. U. S. Nat. Mus., vol. i, p. 48.). To this Dr. H. A. A. Nicholls subsequently made some additions (ib. vol. iii, p. 254). Another collection was, however, made there in 1887 and 1888 by Mr. Geo. A. Ramage, the naturalist employed by the joint committee of the Royal Society and British Association for investigation of the fauna and flora of the Lesser Antilles; and in 1863 Rev. E. C Taylor spent two weeks in Dominica making a small collection (cf. Ibis, vol. vi, p. 157).

The island itself presents many difficulties to a collector; for, aside from its being very mountainous and heavily wooded, as mentioned above, there are no means of transportation for baggage, etc., except on the heads of natives; while the collector himself must depend upon his own legs or one of the small, and not too lively, native ponies, there being but two carriages on the island and their use being restricted to the immediate vicinity of the towns and along the coast for a few miles, as there are no carriage roads whatever in the interior, or crossing the island, and in many places even the trails are very poor.

Our collections were, for the most part, made from four camps, as follows: at Laudat, a little hamlet at an elevation of about 1600 feet, at the head of the Roseau Valley, and about ten miles from Roseau, the principal town on the island; at Spring Hill, situated on the side of the same valley at about the same elevation as Laudat, or a little less, and distant about three miles from the latter place; at Bass en-ville, situated on a high plateau in the interior of the island, about half way across, and at an elevation of about 2000 feet; and at Lasswa, situated on the eastern or windward side of the island.

We found the inhabitants uniformly kind, courteous, and anxious to help us in every way. Our thanks are especially due to the Governor of the Leeward Islands, and to the President and Members of the Council of Dominica for their kindness in giving us permission to collect there, placing at our disposal the house for the Government engineers at Bass-en-ville, and for courtesy in many ways. We are no less indebted to the following named gentlemen residing on the island:—to Mr. James, the Inspector of Police, for valuable aid in many ways; to Dr. H. A. A. Nicholls, well known by his contribu-

tions to science from the fauna and flora of this island, for aiding us by his own knowledge of the birds, the best collecting grounds, and much general information and help; to the Bishop of the Roman Catholic Church and his priests for their hospitality and aid, especially in allowing us to enter the churches in search of some species of bats and the owl (*A. flammea nigrescens* Lawr.); to Mr. A. Davis Reviere and his brother Emory Reviere, of Clark Hall, for their great kindness and hospitality while we were in the Layou Valley; to Mr. Hennessey Dupigny, who accompanied us part of the time, and to whose consummate woodcraft and knowledge of the habits of the birds we are in a large measure indebted for our success and for many valuable specimens, which we should otherwise have been unable to procure; and to Mr. Arthur Ogilvy, Mr. A. Frampton, and Mr. Wm. Gellion, for many acts of kindness and aid. In addition to these above named gentlemen many others gave us much valuable assistance and all endeavored to make our stay there as pleasant and profitable as possible.

For the working up and identification of the collections we are indebted to the following gentlemen:—to Mr. J. A. Allen of the Am. Mus. of Nat. Hist. for the identification of the birds and mammals, for certain notes on the same which appear in the following list, and for valuable advice on the nomenclature used therein; to Prof. E. D. Cope for the identification of the Reptiles and Batrachians, and for notes on the same; to Mr. Sanderson Smith of the Am. Mus. of Nat. Hist. for the identification of part of the Mollusca; and to Prof. S. I. Smith of Yale Univ. for the identification of the Crustacea.

Notes on the Mammals.

The mammals of Dominica are very few indeed, those indigenous being mainly bats, of which there are several species that are quite common, but rather difficult to procure owing to their nocturnal habits. We procured but one, which Mr. Allen examined and says is probably *Vespertilio nigricans*, at least it so nearly resembles it that he cannot see wherein it differs without having more material.

These small bats, of this species or very closely resembling it, were very common about Bass-en-ville in the evening, but though I shot several I lost all but this one among the high grass and bushes, the light being very dim when they appeared, and in the morning we could never find any trace of them, they probably having been eaten or carried off by the crabs (*P. dentata*) which were always on

the watch for anything in the nature of meat that we might throw out. Besides these small bats we several times observed much larger ones of one or more species which I suppose were some kind of fruit bats, but we were unable to procure any, as we never saw them except when it was quite dark, too dark to shoot with any accuracy at an object moving so swiftly and seen for so short a time as they were when suddenly darting across the narrow trail bordered by thick woods on each side. These large bats were seen almost exclusively at a short distance from the coast, and I think they are confined to the less elevated portions of the island.

Besides the bats, there are found here a species of agouti and an opossum, or opossum-like animal, called "Manacou" by the natives, the latter having been introduced, but both are now quite common, and the agouti forms quite an article of diet among the natives. The common rats and mice are exceedingly abundant, but we saw no native ones at all.

List of Birds obtained and observed, with Notes on their Habits, Nests, and Eggs.

PLATES XXV, XXVI, XXVII.

The following notes on the habits are from the combined observations of my brother, A. H. Verrill, and myself. The descriptions of the nests and eggs themselves, unless otherwise stated, I have made from the specimens actually obtained by my brother and now in the Peabody Museum, but the notes on the nesting habits, etc., are mainly by him.*

Unless otherwise stated the measurements given were made from the fresh specimens at the time of collection, and are given in inches in the following order: length, wing, tail, extent. In some cases, where they may be useful for comparison, I have added measurements of the bill (exposed culmen unless otherwise stated), and tarsus, both made from the skins. The measurements of the eggs are in decimals of an inch. In most cases I have given the measurements of several specimens to show the variation.

The sex was carefully determined in all cases by dissection, and in one or two cases the previous conclusions with regard to the plumage of the adult female are shown to have been erroneous.

* As I did not arrive in Dominica until the latter part of April, when the breeding season was nearly over, we took few nests after my arrival.

The identification, as previously stated, was by Mr. J. A. Allen, whose authority is too well known to admit of any doubt, even had he not been aided by many of Mr. Ober's type-specimens.

The list probably comprises very nearly all of the land birds, but comparatively few of the aquatic species, as our time was too limited to warrant spending it on these latter, which are, for the most part, much more widely distributed and better known.

It is a rather striking fact that nearly all of these islands have a number of species of Passerine Birds peculiar to each, though represented in the adjacent ones by closely allied species. The entire absence of woodpeckers on this island, covered with trees, is another peculiarity. In a few cases we have added species not previously known in Dominica to the fauna of this island, and in several cases have taken species seen, but not identified, by Mr. Ober.

The vernacular names, given in this and the following lists, are those used by the natives and are commonly in the French patois of the island. When the native name was evidently derived from the French, yet differs materially from it, I have given the patois pronunciation, expressed as well as possible by English spelling, with the original French word and English equivalent in parentheses. In many cases it has been impossible to even guess at the original from which the native word has come, and in other cases it has undoubtedly been derived from the Caribs, a number of whom still inhabit the island; but, as both the Patois and Carib languages are wholly spoken ones, I have only been able to preserve the sound, as nearly as possible, by phonetic spelling. The following abbreviations are used: Fr. = French, Pat. = Patois, Ca. = Carib, Eng. = English.

It is a rather peculiar fact that the natives know nearly all the birds and distinguish even closely allied species by different names. They also know and readily recognize them by their notes and are generally able to identify the nests and eggs.

The arrangement used is that adopted by the Amer. Ornith. Union.

Order, LONGIPENNES.

Family, LARIDÆ.

1. **Sterna fuliginosa** Gmel. "Twar-oo" (Pat.).

A number of terns, probably of this species, were seen at different times flying about the harbor at Roseau. Several other species of terns were also seen but not near enough to identify with any certainty. No specimens of these, and many other marine birds were obtained, owing to lack of time, as has been previously stated.

Order, TUBINARES.

Family, PROCELLARIIDÆ.

Much has been said and many stories are told of the so-called "Diablotin," which the inhabitants of this island say used to make its burrows and nests on the mountain which is called Mt. Diablotin, the highest peak in Dominica. All agree, however, that none have been seen there for a long time, twenty years or more, so that it is very difficult to get a good description of what this bird was like. However, the Bishop of the Roman Catholic Church kindly showed my brother an old book in his possession which contained a picture that showed the "Diablotin" to have been some sort of a petrel, but to what genus or species it belonged it was impossible to tell. Further than this we could learn nothing of importance concerning it. Very likely it was the same as the "Diablotin" of Guadeloupe, (cf. Auk. viii, p 61).

Order, STEGANOPODES.

Family, PHAETHONTIDÆ.

2. **Phaethon flavirostris** Brandt.

Common. Breeds in the cliffs along the coast on the leeward side of the island. Though no specimens were taken there is no doubt of the identity of this bird as they could be closely observed.

Mr Ober took this species in the same localities where it was observed by us.

Family, PELECANIDÆ.

3. **Pelecanus fuscus** Linn.

Abundant all through the West Indies. Several seen about the island.

Family, FREGATIDÆ.

4. **Fregata aquila** (Linn).

Seen several times flying over, high in the air.

Order, ANSERES.

Family, ANATIDÆ.

According to the natives, ducks of one or more kinds are sometimes seen, in the fall, in the Mountain Lake and fresh water streams. We ourselves saw none at all.

Order, HERODIONES.

Family, ARDEIDÆ.

5. **Ardea herodias** Linn "Crabier noir," Pat and Fr (Black Crab-eater) "Black Crabier," Pat "Black Gaulin," Pat

This bird was described to us under the above Patois names by Mr. Hennessy Dupigny and others, and one or two were seen in the river at Bass-en-ville, but no specimens were obtained.

Though not observed by Mr. Ober in Dominica or Guadeloupe, he took it in nearly, if not all, the other islands visited by him, and Dr. L'Herminier records it from both Guadeloupe and Martinique in a "Catalogue des oiseaux observés à la Guadeloupe par le Docteur F. L'Herminier, de 1827 à 1844," given by Mr. Lawrence in connection with Mr. Ober's list (Proc. U. S. Nat. Mus., vol. i, 1878, p. 450).

A smaller "Black Crabier," which was described as being found in Dominica by several of the inhabitants, is probably *A. cærulea*, taken there by Mr. Ober.

6. **Ardea egretta** Gmel. "Aigrette," Pat. and Fr (Egret) "White Gaulin," Pat.

Not particularly rare along the rivers, especially the Layou River. Seen several times in the neighborhood of Bass-en-ville. Though several were observed no specimens were secured, partly owing to the shyness of the birds themselves and partly to our own lack of time, but I am very sure of the identity, as I am familiar with the above species, having seen and shot it many times in Florida. This bird was not observed by Mr. Ober among the Lesser Antilles at all, though "a large White Heron" was described to him as visiting Barbuda, but Dr. L'Herminier records it from both Guadeloupe and Martinique.

As with the last species, the natives also described another "White Gaulin," smaller than this one, which is probably *A. candidissima*, taken there by Mr. Ober.

7. **Ardea virescens** Linn. "Kialoo," Pat. "Green Crabier," Pat *Butorides virescens* (Linn); Taylor Lawr., and Scl Lists

Resident. Common along all the streams. Habits the same as in the U. S.

Irides yellow, legs and feet greenish yellow. ♂ 18–6½–2⅝–25, bill 2⅛, tarsus 2. Sex? (from skin), wing 7¼, tail 2¾, bill $2\frac{3}{10}$, tarsus 2.

8. **Nycticorax violaceus** (Linn) 'Crabier Pat. and Fr (Crab-eater) "Night Gaulin," Pat

Nyctanardea violacea (Linn), Scl List

Common, but on account of its nocturnal habits not very often seen. Most of our specimens were procured by Mr. Hennessey Dupigny near Shawford in the Roseau Valley.

Iris orange, legs and feet yellow, bill black. Sexes alike, young very different, somewhat resembling the young of *N. nycticorax naevius*. ♂ 26–12 4½–4½, bill 3·1, tarsus 3·6. In other specimens, wing 11½–11⅝, bill 3·0–3·1, tarsus 3 4–3 5.

"Nest built in the tallest trees Eggs pale bluish green."—(A H V.)

Order, PALUDICOLÆ.

Family, Rallidæ.

9 **Ionornis martinica** (Linn.) 'Poule d eau," Pat and Fr (Water-hen).

Porphyrio martinicus (Linn), Lawr. List

A bird described to us by several of the inhabitants under the above Patois name was very likely this species, a specimen of which was shot there after Mr. Ober's departure but which was saved for him (Proc. U. S. Nat. Mus., vol i, 1878, p. 197). Said by those who described it to be rare. Given from Guadeloupe and Martinique by Dr. L'Herminier.

Order, LIMICOLÆ.

Family, Scolopacidæ.

10. **Ereunetes pusillus** (Linn) 'Bécasse," Pat and Fr. (Snipe)

Ereunetes petrificatus (Illig) Lawr List Birds Lesser Antilles (P. U. S N M., vol i, 1878, p 488)

A sandpiper seen by us several times, but not procured, was probably this species. Mr. Ober also observed a sandpiper here, "Species undetermined," which Mr. Lawrence referred to this species in his "Catalogue of the Birds noted from the Lesser Antilles by Mr. Ober." Obtained by Dr. Nicholls who states that it is "common at the mouths of the rivers during the hurricane months." (cf. Proc. U. S. Nat. Mus., iii, p. 256).

11. **Actitis macularia** (Linn)

Tringoides macularius (Linn.), Lawr List.

Rather common. Seen on the rocks in the beds of streams and along their shores. No specimens were taken from lack of time but I have no doubt of the identity of this bird, so familiar to every North American collector. Also taken there by Dr. Nicholls.

Order, COLUMBÆ.

Family, COLUMBIDÆ.

12. **Columba corensis** Gmel "Ramier," Pat and Fr (Ringdove) "Black Ramier," Pat

Common in the heavy woods in the interior and among the mountains. Very arboreal. Mr. Ober states that it "never touches the earth"; whether this be so or not we never observed it except while in the trees or on the wing. Feeds on the fruit and seeds of certain trees, particularly the gommier tree. Being excellent eating it is much hunted for food during the open season, and hence is very shy and hard to shoot. Its loud cooing, resembling that of the domestic pigeon, but much louder, may be heard for a long distance, but even when one has carefully followed it up and stands beneath the very tree where the bird is, it is extremely difficult to actually see it

Sexes alike. Iris yellow flecked with red, skin around the eyes orange, legs and feet dull coral red, bill red at the base and yellow or horn-color at the tip. ♂ $16\frac{1}{2}$–9–6–24 ; $16\frac{3}{8}$–$8\frac{1}{2}$–$6\frac{1}{4}$–$26\frac{1}{2}$.

13 **Columba leucocephala** Linn "White-headed Ramier," Pat

Rare. When first told of this bird by the native hunters I was inclined to think they were mistaken, as I did not then know of its having ever been recorded from this or any of the adjacent islands, but they were very positive and described it well, but stated that it was very rare though found in the same localities and in company with the common "Ramier." While at Bass-en-ville, however, I, myself, saw several specimens on the wing, the white head showing very plainly. Though in spite of every endeavor we were unable to procure any. I do not think there is any doubt about its identity, and am still in hopes of having one or more sent to me, at no distant date, by our friends in Dominica.

This species is also recorded by Dr. L'Herminier from Guadeloupe and Martinique, the islands adjacent to Dominica, and lying respectively north and south of it. Mr. Ober records it from Antigua and Barbuda, but no further south.

14. **Zenaida martinicana** Bonap. "Tourterelle," Pat. and Fr (Turtledove)

Abundant, but shy and retiring. Found principally near the coast, apparently not reaching to any great altitude. Like the "Ramier" and "Perdrix" it is much hunted as a game bird and, like the latter, is often kept in captivity.

Sexes alike. Iris brown, bill black, legs and feet red. ♂ $12\frac{1}{4}$–$6\frac{1}{2}$–$4\frac{1}{2}$–20; 13–$6\frac{1}{4}$–$4\frac{1}{8}$. ♀ 13–$6\frac{3}{8}$–$4\frac{1}{8}$.

15. **Columbigallina passerina** (Linn.) "Ortolan," Pat. and Fr. "Ground Dove," Eng.

Chamæpelia passerina (Linn.), Lawr. and Scl. Lists.

Abundant along the edges of the cane-fields and in the roads along the coast, particularly on the leeward side of the island. Not found among the mountains. Quite tame and unsuspicious. Many are captured and sold for cage birds.

Sexes similar. Iris orange, legs and feet flesh-color, bill brown, lower mandible lighter at the base. ♂ 7–$3\frac{1}{4}$–$2\frac{1}{2}$; 7–$3\frac{1}{16}$–$2\frac{1}{2}$; 7–$3\frac{1}{8}$–$2\frac{1}{2}$, 7–$3\frac{3}{16}$–$2\frac{1}{2}$. ♀ $7\frac{1}{4}$–$3\frac{1}{4}$–$2\frac{1}{4}$–10; 7–$3\frac{1}{4}$–$2\frac{1}{2}$. In all the specimens, exposed culmen $\frac{7}{16}$, tarsus in ♂ 0·67, tarsus in ♀ 0·61.

16. **Geotrygon montana** (Linn.) ♂ "Perdrix rouge," ♀ "Perdrix noire" Pat. and Fr. (Red Partridge, Black Partridge.)

Rather common in heavy woods, particularly near the streams and rivers. Found mainly among the mountains. Like the "Ramier" it is much hunted as a game bird and is consequently shy. The native name of "Perdrix" (Partridge) is very appropriate, as it is very terrestrial in its habits, spending most of its time on the ground, frequently running instead of flying to avoid danger, and in many of its habits and general appearance it more resembles the quails or partridges than the doves.

It is a very quiet bird, rarely giving utterance to any sound. The dark colored (perhaps immature), female is much less frequently shot or seen than her more brilliantly colored mate.* Of the seven specimens in our collection only one is a female and dark brown, while the six males are all in the red plumage. Like the last it is frequently kept in captivity as a cage-bird.

Iris of the male varies from orange brown to yellow brown or ocher yellow, in the female it is yellow. Legs, feet, bill and naked skin surrounding the eye, pink in the male; darker red in the female when in the brown plumage. ♂ $11\frac{1}{2}$–$6\frac{1}{8}$–$3\frac{1}{4}$–$19\frac{3}{8}$; 11$\frac{1}{4}$–6–$3\frac{3}{4}$–$19\frac{1}{4}$. ♀ $11\frac{1}{2}$–6–3.

"Nest built on or near the ground, generally of a few leaves loosely put together. Eggs slightly tinged with buff, resembling those of *Bonasa umbellus*."—(A. H. V.)

* The adult female has been described as like the male, and the dark-brown plumage given as that of the young (Ridgway, Man. N. A. Birds), but natives say that the female is always brown, and our small series seems to bear out this assertion, for though I looked particularly for a red female or a brown male, I never found either. Mr. Cory, too, describes the sexes as different in his "Birds of the West Indies" (Auk, vol. iv, p. 119).

17. **Geotrygon mystacea** (Temm) "Perdrix keesong," Pat (probably from Fr. Perdrix croissant, Crescent Partridge.).

The inhabitants told us of a "perdrix" called by the above Patois name and stated that it was found in much the same localities and had habits very similar to the former species but was much rarer.

Before I arrived one was shown to my brother, by Mr. Hennessey Dupigny I think, but it was so badly shot and injured that my brother, not realizing at the time its rarity on the island, did not preserve it. Though I saw no specimens myself, I have no doubt from the descriptions of my brother and Mr. Dupigny that the Dominican "Perdrix keesong" is the above species, recorded from both Guadeloupe and Martinique by Dr. L'Herminier, and taken on the former island only, by Mr. Ober, and according to him, there called "Perdrix croissant" from the white crescent-shaped mark under the eye. Also given from St. Lucia and Guadeloupe by Mr. Cory (Auk, vol. iv, p. 118), and taken at Martinique by Mr. W. B. Richardson (ib. p. 96).

Order, RAPTORES.

Family, Falconidæ.

18. **Buteo latissimus** (Wils) "Malfeenee," Pat
Buteo pennsylvanicus (Wils), Lawr and Scl Lists.

Common, widely distributed, and much more tame and unsuspicious than in the United States. We found it particularly common in the vicinity of Bass-en-ville. Observed from the time we arrived till we left. In several of the specimens taken, the stomach contained nothing but large caterpillars. All our specimens, six in number, were in the fully adult plumage.

Sexes alike. Iris white. ♂ 15½–10⅜–6¾–32. ♀ 15¼–10½–6½–33; 15½–10⅜–6½-33. In all specimens; bill, cere to tip, ¾; tarsus 2.

19. **Falco columbarius** Linn. "Nonnette," Pat. and Fr (Osprey); "Gue Gue," Pat., "Killee Killee," Pat.; "Mountain Hawk," Eng

Rather rare but generally very tame. Neither Mr. Ober nor Mr. Ramage took this bird in Dominica, nor is it mentioned at all in Mr. Lawrence's List of the Birds observed among the Lesser Antilles by Mr. Ober, and Mr. Taylor does not mention seeing it anywhere among the West Indies, all of which seems rather strange, as we took two specimens, a pair (Mar. 7 and April 12), and saw others, and my brother found its nest, proving it to be a resident, at least during the breeding season. Dr. L'Herminier, however, gives it

from both Guadeloupe and Martinique, it was also taken in the latter island, by Mr. Richardson (Auk, iv, p. 96), and at St. Kitts by Mr. C. S. Winch (ib. viii, p. 48) and recorded from the Greater Antilles and Grenada by Mr. Cory (ib. iv, p. 43)

Apparently it is mainly confined to the mountains, as all we observed were seen at quite an altitude, and the common English name is "Mountain Hawk," while the other names, with the exception of the first, are also applied to the following species. I am at a loss to account for the name "Nonnette" (Osprey) as applied to this bird.

Iris (in specimens taken), brown in the male, red in the female; legs and feet yellow; bill dark horn-color, lighter at the base. ♂ $11\frac{1}{2}$–$7\frac{5}{8}$–5. ♀ $11\frac{1}{2}$–$7\frac{1}{2}$–5.

"Eggs all badly incubated Breeds in hollow trees or on cliffs"—(A H V)

20. **Falco caribbæarum** Gmel 'Gue Gue," Pat, "Killee Killee" Pat
Tinnunculus sparverius antillarum (Gmel), Lawr List
Tinnunculus caribbæarum (Gmel); Scl List

Rather common, but not abundant. It much resembles *F. sparverius* in its habits and notes. It is a rather peculiar fact that all the specimens obtained, four in number, were males. Taken from April 14 to May 24.

Irides brown; cere, eyelids, feet and tarsi, orange yellow; bill bluish grey at the base, black at the tip ♂ 11–$6\frac{1}{2}$–$5\frac{1}{2}$–20; $11\frac{1}{2}$–$6\frac{1}{2}$–$5\frac{3}{16}$; $11\frac{1}{2}$–$6\frac{5}{8}$–$5\frac{3}{16}$. In all specimens, tarsus $1\frac{1}{4}$, bill (cere to tip), $\frac{1}{2}$.

21 **Pandion haliaetus carolinensis** (Gmel) Fish Hawk
Pandion haliaetus (Linn), Lawr. List

Seen several times flying over

Family, STRIGIDÆ.

22. **Strix flammea nigrescens** Lawr "Shawah," Pat (probably from Fr Chat-huant, Screech Owl), "Owl," Eng

Rather rare. Like the European species, it is found principally around old deserted houses, in the church towers, and similar places, where it also breeds. This bird, like many of its family elsewhere, is regarded with superstition by the natives and looked on as a "Jumbie Bird," or one possessed of evil spirits.

Sexes unlike. Irides dull, yellowish brown; feet and legs dark brown; feet and toes very sparsely feathered; bill very light yellow. ♂ (from skin), wing $9\frac{1}{2}$, tail $4\frac{1}{4}$, tarsus 2.

Order, PSITTACI

Family, PSITTACIDÆ.

23. **Amazona augusta** (Vig.) "Cicero," Ca

Chrysotis augusta (Vig.), Lawr and Scl Lists

Common in the interior and on the windward side of the island where it is found among the mountains at quite an elevation. This beautiful bird inhabits the thickest and most impenetrable forests where the mountain palms and gommier trees grow, the seeds and fruit of which, together with the young shoots of the former, make a large part of its diet.

They are much hunted for food during the time the game law is off, being then occasionally for sale in the market at Roseau, consequently, though common in the particular localities where they live, they are exceeding shy and difficult to procure. Even when within gunshot it is very hard to distinguish their green and purple plumage among the dense foliage of the high trees. They are generally found in small flocks or in pairs and are not infrequently seen flying over at a distance. As Mr. Ober has observed, their calls are heard mainly for a short time in the early morning and towards evening, and when disturbed, as by a gunshot. Their notes are mainly a shrill whistle, a sharp scream, and a series of crescendo yells.

When kept in captivity, as they sometimes are, they make fairly good talkers. According to the natives, the nest is generally built in a hole at the top of a dead palm, but it is very rarely found; one old Carib, a man who had spent his life in the woods, said he had never found but one.

It was mainly to procure these truly Imperial Parrots, so seldom seen in collections, that our trip was made to Bass-en-ville, which is a single house in the primeval forest, and only to be reached by one of the worst trails I have ever traveled, and I have spent a number of months among the Sierra Nevada Mountains. This trip, however, well repaid us for our trouble, as it was there that we took many of our best birds and other specimens, but though parrots were seen nearly every day, and we were accompanied by Mr. Hennessey Dupigny and another hunter, our united efforts secured but two of these shy birds in the ten days we were there.

One of our specimens is a female and the other was so mutilated by a shot as to render the determination of sex impossible, but they are alike in plumage and I can see no difference between them and Mr. Lawrence's description of a male taken by Mr. Ober.

Iris red; bill dark horn-color with a light spot on each side of the upper mandible at the base; legs and feet dark brown. ♀ 21–11¼–8¼–36½; sex undetermined, 19¾–10½–7½–35½.

24. **Amazona bouqueti** (Wagl.). "Perroquet," Pat and Fr (Parrot)
Parrot sp ?; Lawr. List
Chrysotis nichollsi Lawr; Proc U. S Nat Mus. III, p. 254, 1880
Chrysotis bouqueti (Wagl), Scl List

Found in the same localities, but apparently much rarer than the "Ciceroo" and like it very wild and difficult to procure.

Generally seen in rather larger flocks, otherwise the remarks with regard to the habits and notes of *C. augusta* apply equally well to this species. The notes of the two species can generally be distinguished by a person familiar with them, but the difference between the yells of two parrots is something very difficult to indicate on paper. These latter are also said never to become good talkers.

We succeeded in procuring but one specimen, a male. Mr. Ober did not take this bird at all, though he mentions a parrot "about the size of our North Carolina Parrot but more robust"; but in 1879 and 1880 Dr. Nicholls sent two small collections of Dominican birds to the Smithsonian, and among them were three specimens that Mr. Lawrence described as *C. nichollsi*, giving several differences between it and *C. cyanopis* (Vieill.) and *C. bouqueti* (Bechst). Our specimen agrees very closely with his description in all points but one. Mr. Lawrence says "the breast and abdomen are tinged with yellow" and mentions this as one of the differences between *C. nichollsi* and *C. bouqueti*, but in our specimen the abdomen is green with many of the feathers dull red at the base and there is a band of scarlet ¾ of an inch wide, extending across the upper part of the breast, and half way around to the back on each side, and below the band, in the middle of the breast, are two or three scarlet and yellow feathers. In the specimens at the Am. Mus. of Nat. Hist. this band is entirely lacking. Mr. Cory, however, in his "Birds of West Indies," 1889, p. 186, mentions a "patch of dull red mixed with yellow on the upper part of the breast joining the throat"; but our specimen differs from his description in having the red, wing speculum covering three instead of two feathers and in a few other points and he does not mention the red on the base of the abdominal feathers nor the dark blue on the outer webs of the primaries and outer tail feather, so that in some respects our bird more resembles his description of *C. versicolor* (Müll.).

Judging from the various descriptions and our own specimen this species is subject to great variation in plumage, perhaps due partly to sex, age, and season.

Iris orange; bill light horn-color, running into black at tip of upper mandible; legs and feet brown. ♂ (from skin), wing $9\frac{1}{2}$, tail 6, bill (chord of culmen from cere) 1.20.

Order, COCCYGES.

Family, CUCULIDÆ.

25. **Coccyzus minor** (Gmel.). "Coulavoecou," Pat; "Coucoumioc," Pat. (Fr. Coucou manioc, Manioc or Cassava, Cuckoo).
Coccyzus seniculus Vieill.; Tayl. List.

Not uncommon, locally quite common, as at Bass-en-ville, where a number were seen and heard and several taken.

In habits and notes it much resembles our common Yellow-billed Cuckoo (*C. americanus*).

Iris brown or red; upper mandible black, lower mandible yellow, black at the tip; legs and feet black. Sexes alike in plumage, female apparently larger than the male. ♂ $13-5\frac{3}{8}-6\frac{5}{8}-15$; $13\frac{1}{2}-5\frac{5}{8}-6\frac{1}{4}$; $12\frac{3}{4}-5\frac{1}{4}-6-16\frac{1}{2}$. ♀ $13\frac{3}{4}-5\frac{3}{4}-6\frac{7}{8}-17\frac{1}{2}$.

Order, ALCYONES.

Family, ALCEDINIDÆ.

26. **Ceryle alcyon** (Linn.). "Calbasco," Pat

Rather rare and shy. Seen several times. Though no specimens were obtained it was undoubtedly this species, which Mr. Ober also saw but did not take.

The natives insisted that there were two entirely different birds, both called by the above Patois name, and stated that the other was rare and had a long bill with teeth or notches along its sides, but the description was so imperfect that it was impossible to tell what bird it was, and though we used every endeavor and offered a good price we were unable to procure any; still I am in hopes that one of our friends who helped us to secure so many rare birds, may yet send us one of these, which I am sure from the description given us is something unlooked for in the fauna of this island.

Order, MACROCHIRES.

Family, MICROPODIDÆ.

27. **Cypseloides niger** (Gmel.) "Hirondelle," Pat. and Fr. (Swallow).

Not so common as the following species, though generally seen in the same localities and at the same time, but usually flying much higher, and so is more difficult to procure. Two specimens only were obtained. Neither Mr. Ober nor Mr. Ramage procured this bird in Dominica, though the former gentleman speaks of seeing "a species of swift intermediate in size between the small swift and the large martin," which was undoubtedly this bird.

Iris, bill, legs, and feet black. Sex ? $6\frac{3}{8}$–6–$2\frac{5}{8}$.

28. **Chætura dominicana** Lawr. "Hirondelle," Pat. and Fr.

Given provisionally as *Chætura poliura* (Temm.) by Mr. Lawrence in his list. Afterwards described as above. (Ann. N. Y. Acad. Sci., vol. i. 1879, p. 255.)

Very common and widely distributed. Particularly abundant near Spring Hill and about the head of the Roseau Valley. Also seen in numbers at Casata Garden and at Bass-en-ville. As Mr. Ober states, they generally appear for a short time after a rain and then disappear again. I can see no trace in our specimens of the whitish edging to the upper tail coverts mentioned by Mr. Lawrence. Very likely it is a seasonal variation.

Sexes alike. Iris and bill black, legs and feet brown. ♂ 5–$4\frac{5}{16}$–$1\frac{3}{4}$–$10\frac{1}{4}$; $4\frac{3}{4}$–$4\frac{5}{8}$–$1\frac{3}{4}$–$10\frac{1}{2}$. ♀ $4\frac{3}{4}$–$4\frac{7}{16}$–$1\frac{5}{8}$–$10\frac{1}{4}$; $4\frac{3}{4}$–$4\frac{7}{16}$–$1\frac{3}{4}$–$10\frac{3}{8}$; $4\frac{3}{4}$–$4\frac{5}{8}$–$1\frac{5}{8}$. Tarsus $\frac{3}{8}$ in all specimens.

Family, TROCHILIDÆ.

29. **Eulampis jugularis** (Linn.) "Fou Fou Mardet," Pat. (Fr. Fou Fou, Crazy Crazy, in allusion to their eccentric motions while on the wing.)

Common, though rarely found in the immediate vicinity of the coast. Its principal range seems to be from 500–1500 feet elevation and in this belt it is very common, especially in the plantain, banana, and lime plantations where it may be seen hovering about the flowers, perching every now and then on some convenient leaf or twig to rest and preen itself. Like all of its family that are found on the island, it is very tame and permits a close approach.

Formerly many of this and other species were slaughtered for millinery purposes, but of late years they have been strictly protected by law. Mr. Taylor speaks of finding this bird in Dominica, but less commonly than the following species, whereas our experi-

ence was directly the reverse, this species outnumbering *E. holosericeus*, I should say, by at least four to one, and closely approaching *B. exilis* in numbers, so that it may have increased since he was there. He also speaks of its frequenting "thick shady places," a habit that we failed to observe.

The females closely resemble the males but the colors are not quite so bright, particularly the crimson on the throat and breast, and they seem to be slightly smaller.[1] The bill (exposed culmen), varies greatly in length. Iris, legs, feet, and bill black. ♂ $5\frac{1}{2}$–$3\frac{1}{8}$–$1\frac{5}{8}$–$7\frac{5}{8}$, bill ·92; $5\frac{1}{4}$–3–$1\frac{5}{8}$–$7\frac{1}{2}$, bill ·85; $5\frac{1}{8}$–$2\frac{7}{8}$–$1\frac{5}{8}$, bill 1·03. ♀ $5\frac{3}{8}$–$2\frac{11}{16}$–$1\frac{1}{2}$–7, bill 1·04; 5–$2\frac{3}{4}$–$1\frac{9}{16}$, bill ·97; 5–$3\frac{1}{8}$–$1\frac{7}{8}$, bill ·85.

[1] Nest always placed at a considerable distance from the ground. One taken April 9th was fully sixty feet from the ground in a catalpa tree"—(A. H. V.)

This nest, though entirely finished, contained no eggs and evidently had not been used. It is saddled on a good sized crotch (the main branch $\frac{5}{16}$ inch in diameter), that grew in a nearly horizontal position. The nest is very compact, slightly elliptical in shape on top, and composed of the brown scales from the leaves of ferns, probably mainly tree-ferns, with a few large pieces of grey lichens on the outside, mostly near the bottom. The bottom is covered with greenish white down, probably from young fern leaves, and the whole nest is very firmly fastened to the branch by the same material, running entirely around the twig. Inside, it is lined with down from the silk-cotton tree. From side to side, in the largest place, it measures $2\frac{1}{8} \times 1\frac{3}{4}$ and is $1\frac{3}{4}$ high. The cavity is $1\frac{1}{8} \times 1$ on top and $\frac{5}{8}$ deep. Plate XXV, fig. 1.

80. **Eulampis holosericeus** (Linn.) "Fou Fou Tête-longue" Pat. and Fr. (Crazy Crazy Long-head.)

Not so common as the preceding, found at a rather greater elevation (about 750–2000 feet), and principally on the windward side of the island, though by no means rare on the leeward side in certain localities. In common with the last and *B. exilis* it is particularly fond of the plantain and banana patches, which were our principal collecting grounds for these three species.

Mr. Taylor states that he found this the most abundant humming-bird in Dominica, but according to our experience it was the least so, with the exception of *T. bicolor*, which was not observed by him, so that it seems as though this species must have greatly decreased or the others increased since he was there, which well might happen in the twenty-seven years between his visit and ours.

Sexes much alike, but the male rather brighter than his mate. Iris, bill, leg, and feet black. As in the last species the length of the bill is very variable. The measurement given in all cases is the chord of the exposed culmen. ♂ $4\frac{3}{4}$–$2\frac{1}{4}$–$1\frac{7}{16}$–$5\frac{1}{2}$, bill ·80; $4\frac{3}{4}$–$2\frac{7}{16}$–$1\frac{7}{16}$, bill ·82; $4\frac{1}{2}$–$2\frac{5}{16}$–$1\frac{1}{2}$, bill ·96. ♀ $4\frac{3}{4}$–$2\frac{3}{8}$–$1\frac{7}{16}$–6, bill 1.01.

"Nest generally a deep pouch-shaped structure fastened by one side to a perpendicular twig, generally at some height (20–40 feet), from the ground"—(A H V)

Five nests are in the collection.

One taken at Laudat, April 10, contained no eggs, is pouch-shaped, fastened to the upright stalk of a plant, and is composed of the fine, brown scales from ferns, mentioned above, with a number of pieces of bark and leaves, from the plantain and banana plants, hung loosely on the outside, the whole being bound together by cobweb. It is $2\frac{1}{2}$ high and $1\frac{1}{2}$ in diameter at the top, continuing the same size to within an inch of the bottom and from there tapering down to a point. The cavity is $1\frac{5}{8}$ deep and $\frac{3}{4}$ in diameter.

The second was taken March 28, and contained two young. This is like the last except that it is completely covered with pieces of plantain or banana bark and leaves. It is $2\frac{1}{2}$ high and $1\frac{1}{2}$ in diameter across the top, sloping gradually down to the bottom, which is $\frac{3}{4}$ across. The cavity is $1\frac{1}{8}$ deep and 1 in diameter across the top. Plate xxvi, fig. 2.

The third, taken April 13th, contained two fresh eggs. It is cup-shaped, saddled on a small twig inclined upwards at an angle of about 30°, and is composed like the two already described. It measures $1\frac{1}{2}$ across the top and is $1\frac{1}{4}$ high. The cavity is $\frac{7}{8}$ across the top and $\frac{3}{4}$ deep. The eggs are dead white, elliptical in shape, and measure ·51 × ·34 and ·50 × ·35. Plate xxv, fig. 2.

The fourth, taken April 15th, also contained two fresh eggs. It is cup-shaped and composed like the former ones but with a little down from the silk-cotton tree for inside lining and very few pieces of banana and plantain leaves on the outside. It is $2\frac{1}{4}$ high and $1\frac{1}{2}$ across the top, sloping down to a point at the bottom. The cavity is $\frac{3}{4}$ deep and $\frac{7}{8}$ in diameter. The eggs are like the above and measure ·46 × ·29 and ·47 × ·30.

The last nest contains two eggs. It is cup-shaped and composed like the third. It measures $1\frac{1}{4}$ high and $1\frac{5}{8}$ across the top. The cavity is $\frac{3}{4}$ deep and 1 across the top. The eggs measure ·51 × ·33 and ·51 × ·34, color and shape like the former ones. Plate xxvi, fig. 1.

31. **Thalurania bicolor** (Gmel) "Fou Fou Bleu," Pat and Fr (Blue Crazy Crazy)

Thalurania wagleri (Less), Lawr and Scl. Lists

Rather common. Found mainly at a considerable elevation and in the heavy woods. We never took it at an elevation of less than 1200 feet and apparently it rarely, if ever, descends to the lowlands. Taken in the vicinity of Laudat, at Providence (Mr. Hennessey Dupigny's plantation near Laudat), and near Bass-en-ville. This beautiful bird seems to prefer the seclusion and shade of the deep woods to the sunshine and warmth of the plantations and clearings. In some little opening among the thick mass of trees, vines, lianas, etc, that compose the forests of this island or along some mountain trail that runs through the deep woods, it is generally seen, either hovering about some flower, sitting pruning itself upon some twig or stem, or darting past so swiftly that one sees but a gleam of burnished blue and green. It is rather solitary in its habits, more than one rarely being seen at a time. Only one female was obtained, at Bass-en-ville, May 19, and no others were met with, though nine males were obtained and several others seen. The males too were observed about the nests and sitting on the eggs, but no females.

Sexes very different in plumage. Iris dark brown or black; legs and feet dark brown; upper mandible black; in the male the lower mandible is white, black at the tip; in the female it is dark brown, slightly lighter at the base and black at the tip. ♂ $4-2\frac{1}{4}-1\frac{9}{16}$; $4\frac{1}{2}-2\frac{3}{8}-1\frac{5}{8}-6$; $4\frac{3}{8}-2\frac{5}{16}-1\frac{11}{16}-5\frac{3}{4}$; $4\frac{1}{2}-2\frac{5}{16}-1\frac{3}{8}-6$; $4\frac{1}{4}-2\frac{3}{8}-1\frac{3}{4}$. ♀ $4-2\frac{5}{16}-1\frac{1}{2}-5\frac{1}{2}$. In all the male specimens the exposed culmen measures 0·65 and in the female it is 0·68.

"This bird builds the handsomest nests of all the hummers on the island It is usually built close to the ground, never more than a few feet from it, and generally placed in a large brake-like fern. A number of sets taken, all at a great elevation, 2000–2500 feet"—(A. H V)

One nest, taken April 12, contained "two badly incubated eggs." It is fastened to the frond of a fern, and composed mainly of a fine, short, greyish brown, vegetable fibre, much resembling fur, and a few brown fern scales. On the outside are fastened a few small pieces of gray lichen and the whole is fastened together with spider-web or something so closely resembling it as to be indistinguishable without careful microscopic examination. It measures $1\frac{3}{8}$ across the top, $1\frac{1}{4}$ in height, and the cavity is $\frac{3}{4}$ deep. The eggs are dead white, nearly elliptical, and measure ·46×·30 and ·46×·31. Plate XXVI, fig. 5.

Another nest, taken April 14, containing one fresh egg, is situated on a twig and much like the last, but slightly lined with silk-cotton, and is well covered with small pieces of lichen, each placed with the natural side, of a light greyish green, out. It is $1\frac{3}{8}$ across the top, $1\frac{1}{8}$ high, and the cavity is $\frac{5}{8}$ deep. The egg is like the last two and measures ·54 × ·37. Plate XXVI, fig 4.

A third nest taken near Laudat, March 28, with two badly incubated eggs, is placed in the crotch of a fern frond, but varies from the other two in being composed, on the outside, of the brown scales from stems of ferns with no pieces of lichen, and the inside is very thickly lined with down from the silk-cotton tree. This one measures $1\frac{1}{2}$ across the top, $1\frac{1}{4}$ in height, and the depth of cavity is $\frac{5}{8}$. One egg is too badly broken to measure, the other is ·49 × ·32.

82. **Bellona exilis** (Gmel.) "Fou Fou Bequar," Pat. (Possibly from Fr. besquée, a beak full.)

Orthorhynchus exilis (Gmel.), Tayl. Lawr., and Scl. List

Very common and widely distributed. Though most abundant in the low lands and near the coast, it is also found commonly among the mountains and we took it from every camp. According to our experience this pretty and diminutive species is the commonest of the hummers in Dominica. .

Sexes unlike. ♂ $3\frac{1}{2}$–$1\frac{7}{8}$–$1\frac{3}{16}$, exposed culmen ·31, bill (from rictus) ·68. ♀ $3\frac{1}{2}$–$1\frac{13}{16}$–$1\frac{3}{16}$, exposed culmen ·43, bill (from rictus) ·70; $3\frac{1}{2}$–$1\frac{3}{4}$–$1\frac{1}{4}$, exposed culmen ·44, bill (from rictus) 67.

The nests of this species vary considerably in composition, shape, and mode of attachment. There are nine nests in the collection, no two just alike, the only characters common to all seem to be the presence of more or less brown scales from ferns or tree-ferns used in the composition, and the use of spider web, or some very similar material, in greater or less quantity, to bind the nest together.

Generally the nest is composed mainly of the fern scales, with more or less silk-cotton for a lining, it being entirely absent in only two out of the nine nests, and in three it constitutes about half the total bulk of material. In a number it is also used on the outside, in small quantities, to help bind them together. Six nests are more or less ornamented on the outside with pieces of lichen, after the manner of *T. bicolor*. In one of the other nests the lichen is replaced by small pieces of brown bark and in one where lichen is present there are also a few pieces of dark green moss. (Plate XXVI, fig. 6).

The size is pretty constant but the shape varies more or less according to the location. The usual form is cup-shaped or some modification of it. When saddled on a horizontal twig the sides are generally straight and when in a crotch or on an upright they generally slope somewhat. The diameter across the top is about $1\frac{1}{4}$, three are $1\frac{3}{8}$; the height varies from $1\frac{1}{8}$ to $1\frac{5}{8}$, with the exception of one particularly shallow one that is only $\frac{3}{4}$ high. The cavity varies in depth from $\frac{1}{2}$ to $\frac{7}{8}$, the average being about $\frac{5}{8}$, and in diameter across the top, from $\frac{3}{4}$ to $\frac{7}{8}$.

The mode of attachment and location is quite various. Two are saddled on horizontal branches, one of them at the junction of two smaller twigs; two more are on twigs inclined upwards at an angle of about 45°, one at the branching tip and the other at a crotch; one is in the crotch of a fern leaf, a very pretty and compact nest, thickly covered with spider-web and lined with silk-cotton (Plate XXVI, fig. 3.); another is fastened by the side to two twigs near their junction with a larger branch; another is fastened to the stem of a drooping leaf; and still another by its side to the stem of a vine at the junction of two leaves.

The eggs are dead white and elliptical in shape, like those of the other hummers. We never found more than two in a set. One set of two, taken April 13, were slightly incubated and measure ·50 × ·32 and 51 × ·32; another, taken three days later, had only one egg, fresh, measuring ·47 × ·32; and on March 14 another nest contained two badly incubated eggs, one only saved, ·47 × ·31; and still another taken more than a month later, April 19, also contained two eggs badly incubated, so that only one was saved, measuring ·45 × ·31. Evidently the breeding season varies much.

Order, PASSERES.

Family, Tyrannidæ.

38. **Tyrannus rostratus** Scl. "Pipiree," Pat (from the note)

Common locally. We found it quite plentiful at Bass-en-ville and all up and down the Layou Valley, but rare in the Roseau Valley. A very noisy and lively, but suspicious bird. It delights to perch on the top of some dead tree and utter its loud cry of "pipiree, pipiree," every now and again darting into the air after some passing insect. Its general habits much resemble those of our common Kingbird (*T. tyrannus*).

Sexes much alike. Iris brown; bill, legs, and feet black. ♂ 10–5–$3\frac{1}{2}$–15; 10–5–4–15; 10–$4\frac{3}{4}$–4–$15\frac{1}{2}$. ♀ $9\frac{1}{2}$–$4\frac{1}{2}$–$3\frac{1}{2}$–$13\frac{1}{2}$; $9\frac{5}{8}$–$4\frac{1}{2}$–$3\frac{7}{8}$–15.

84. **Myiarchus tyrannulus oberi** (Lawr.) "La belle Gotet," Pat. (Fr. Gros tête, Large head). "Soleil Coucher," Pat. and Fr. "Sunset Bird," Eng.

Myiarchus, sp. ?; Tayl List. Afterwards referred to *M. erythrocercus*.
Myiarchus oberi Lawr.; Lawr. List
Myiarchus tyrannulus (Müller); Scl. List

Rather common in certain localities, as at Bass-en-ville, but generally very shy and suspicious. Mainly confined to the uplands and mountains. General habits and note somewhat resemble those of *M. crinitus*. The names "Soleil Coucher" and "Sunset Bird" come from its uttering its cry at about sunset.

Sexes alike in plumage, female apparently slightly smaller than the male. Iris dark brown; bill, legs and feet black. ♂ $9\frac{1}{8}$–4–$3\frac{3}{4}$–$13\frac{1}{4}$; 9–4–$3\frac{1}{2}$–12. ♀ 9–4–$3\frac{5}{8}$–12; $8\frac{7}{8}$–$3\frac{3}{4}$–$3\frac{5}{8}$–$12\frac{3}{4}$. 8–$3\frac{3}{4}$–$3\frac{5}{8}$; 8–$3\frac{5}{8}$–$3\frac{1}{4}$.

In all our specimens the bright ferruginous extends along the entire length of the inner webs of the tail feathers, instead of being confined to their outer two-thirds as given by Mr. Lawrence in his original description (Ann. N. Y. Acad. Sci., vol. i, p. 48).

The color of the ventral surface is very variable, grading from light, but bright and pure, yellow in some to dull white, merely washed or tinged with yellow, in others. This variation is apparently not due to sex, season, or locality, as two males taken within three days of each other, at the same place, show as much variation as any.

85. **Blacicus brunneicapillus** Lawr. "Gobe-mouche," Pat. and Fr. (Fly-catcher).

Common, particularly abundant in the heavy woods fringing the main road up the Roseau Valley. An inhabitant of the mountains rather than the lowlands, seeming to generally prefer the deep, high, woods and their borders to the more open groves and plantations of less elevated parts of the country.

Sexes similar. Irides dark brown, legs and feet brownish black, upper mandible black, lower mandible light yellow. ♂ $6\frac{1}{2}$–$2\frac{3}{4}$–$2\frac{3}{4}$–$8\frac{1}{2}$; $6\frac{1}{4}$–$2\frac{11}{16}$–$2\frac{5}{8}$–$9\frac{1}{4}$; 6–$2\frac{11}{16}$–$2\frac{5}{8}$–$8\frac{1}{2}$; 6–$2\frac{9}{16}$–$2\frac{9}{16}$. ♀ 6–$2\frac{3}{4}$–$2\frac{11}{16}$; $5\frac{7}{8}$–$2\frac{9}{16}$–$2\frac{1}{2}$–$8\frac{1}{4}$. In all specimens, bill $\frac{7}{16}$, tarsus $\frac{9}{16}$ to $\frac{5}{8}$.

The only nest obtained was taken with two fresh eggs, April 16. It was placed on a dead limb and is a very frail, loose structure of bark, pieces of banana or plantain leaves, stems, and roots, 2 inches in diameter and $\frac{3}{4}$ high.

The eggs are white with a ring of confluent spots and blotches of a deep reddish brown and a few of lilac, about the large end, in one

egg completely covering this end; the other is not so heavily marked and has a few small spots and blotches over the rest of the surface. They measure ·74 × ·56 and .76 × 55. Plate xxv, figs. 5 and 6.

36. **Elænea pagana martinica** (Linn) "Cheweek," Pat (from the note) *Elænea martinica* (Linn); Tayl, Lawr, and Sel Lists

Common. Generally found at quite an elevation. In habits it much resembles our Pewee (*Sayornis phœbe*).

Sexes alike in plumage. Iris dark brown; upper mandible dark horn-color, lower mandible yellow, running into dark horn at the tip; legs and feet black. ♂ 6⅞–3¼–3–10⅜; 7–3⅛ 2¾. ♀ 6¾–3⅛–2½–10; 7–3⅛–2¾.

"Nest resembles that of *Empidonax minimus* Eggs very variable Generally white, spotted about the larger end with lilac and brown Sometimes closely resembling those of the 'Teeteen' but larger"—(A H V)

A nest in the collection, taken April 16th, contained three fresh eggs. It is compactly built of dry stems, fine grass, and vegetable fibre and is lined with the same and some down from the silk-cotton tree. It measures 2½ in. across the top and 1¾ in high. The cavity is 1⅜ across the top and 1¼ deep.

The eggs are white with fine, light sepia-brown and grey spots (the brown greatly predominating), confluent, and forming a ring about, and even in one case covering, the large end. On the rest of the egg the spots are much lighter. Taken as a whole the markings are more in number and finer than in *D. petechia melanoptera*. The eggs measure ·68 × ·40; ·68 × ·48; ·68 × ·51. Plate xxv, figs. 7 and 8.

Family, Fringillidæ.

37. **Loxigilla noctis schlateri** Allen. ♂ "Penwo," ♀ "Masong" Pat (Probably from Fr Père noir, Black father, and Mère saug, Blood colored mother in allusion to the black male and rather rusty colored female) Also called "Robin" and "Plantain-eater."

Loxigilla noctis (Linn.); Tayl., Lawr, and Sel Lists

Very abundant, especially in the valleys and about the plantations and towns. These were generally the first birds to respond to the call made by sucking the back of the hand, and invariably manifested great anxiety and excitement The sexes are usually very different but subject to great variation. In this connection Mr. Allen, who made a careful examination of our series, writes: "Three males present much variation in the amount of rufous on the lower tail-coverts and the size of the supra-loral spot. These, with other Dominican specimens before me, show that the rufous may be en-

tirely lacking from the lower tail-coverts, or occupy them to the exclusion of black. Two of the females have rufous feathers on the throat, forming, in one of them a small patch; in this specimen there is more or less black mixed through the plumage, giving a patchy effect, suggesting a young male in changing plumage. The sex, however, was carefully determined by dissection. [This specimen also agrees with the other females in size.—G. E. V.] It thus appears that the female sometimes partially assumes the livery of the male, as Mr. Cory has recently found is the case in *Loxigilla violacea* (cf. Auk, viii., 1891, p. 296)."

Irides red or brown; upper mandible black or dark horn, lower mandible lighter, particularly in the female; legs and feet brown. ♂ 6–2¾–2⅛ ; 5½–2⅞–2⅛ ; 5¾–2⅞–2–9½. ♀ 5½–2⅝–2–8½ ; 5½–2¾–2⅛.

"Nest a bulky affair of leaves, sticks, etc. Sometimes domed with the opening on one side. Breeds anywhere. Eggs two to five. A number of sets taken March 28–April 9."—(A. H. V.)

There are two nests of this species in the collection, neither of them domed. One, taken April 1, is composed of pieces of dry plantain and banana leaves, fine stems, roots and dead leaves, and is lined with dried grass, stems, etc. It measures 3 in height and 3¾ across the top. The cavity is 1⅝ deep. This nest contained two fresh eggs, white, blotched and spotted with reddish brown, confluent at the large end, and measuring ·81 × ·57 and ·84 × ·61.

Another nest taken March 31 contained one fresh egg. The nest is like the last and about the same size. The egg markings are of very light brown, not so heavy as in the last, and the large end is not so heavily ringed. It measures ·80 × ·58. On another egg, from a third set, the spots are much more even, rather darker, and form no ring at the large end. This egg measures ·85 × ·58.

38. **Euetheia bicolor** (Linn.) ♂ "Zee Zee Zeb." ♀ "Zee Zee Zay" (Pat.).
Phonipara bicolor (Linn.): Lawr., and Scl. Lists.
Phonipara omissa Jard.; Tayl. List.

Abundant, but like the last, found principally in the neighborhood of plantations and along the trails and paths. Not often seen in the interior nor far from the settlements and cleared lands.

"Note resembles that of the Yellow-winged Sparrow (*Ammodramus savannarum passerinus*)."—(A. H. V.)

Sexes different in plumage. Iris black, legs and feet dark brown, bill black. ♂ 4½–2–1⅝–6½ ; 4¼–2–1½–$6\frac{1}{16}$; 4–2–1⅝. ♀ 4½–2–1½–6½ ; 4½–2–1⅝.

"Nest built of grass, near the ground, among tall weeds or in the cane-fields. Entrance on the side."—(A. H. V.)

The two eggs in the collection are light greenish or dirty white with a number of dark brown spots at the large end and few of the same color scattered over the rest of the egg. They measure ·61 × ·48.

Family, TANAGRIDÆ.

39. **Euphonia flavifrons** (Sparrm.) "Peritch," Pat. (Fr Perruch, Parroquet). "Jaco" Pat and Fr (Parrot).

Rare. We obtained all our specimens, nine in number, from the same tree and saw no others anywhere else. At this particular tree, however, one or more could almost always be obtained, at least by waiting a short time. The natives insisted that there was only one other tree of the same kind on the island and that these two trees were the only places where the birds were found. The tree in question had a parasitic vine of some sort growing on it and it appeared to be on the berries of this vine that the birds fed, as their crops were nearly always full of them.

These birds are very quiet, so that we heard them utter no note beyond a few chirps and twitters. In their actions they are slow and deliberate, crawling rather than hopping about, from which habit, probably, as well as their bright colors, the natives call them "Jaco" and "Peritch," apparently fancying they either are parrots themselves or bear some close relation to them.

The sexes are very similar, the colors of the male brighter than in the female but otherwise the same. Irides black, bill black, legs and feet greyish black. ♂ 5–2⅜–1⅝–8¼ ; 5–2½–1⅝. ♀ 5–2½–1⅝.

"Nest built of sticks, in a hole in a tree. Eggs pure white, sometimes slightly spotted. One nest found, but the eggs were badly incubated and not saved."—(A. H. V.)

40. **Saltator guadelupensis** Lafr. "Grosbec," Pat and Fr (Grosbeak)

Not common. A shy inhabitant of the thickest underbrush and bushes, generally found along the borders of the paths and cleared land. Sexes similar. Of the seasonal variation in this bird Mr. Allen, who examined our series, writes as follows: "This insular form of *S. albicollis* is represented by seven specimens, showing considerable variation in color, the March and April specimens being much greener, especially below, than those taken during the last half of May."

Iris brown; legs and feet brown; upper mandible dark horn-color at the base, yellow at the tip ; lower mandible yellow with a large dark spot on each side at the base. ♂ 9–4⅛–3⅞–13½ ; 9–4–3½–12½ ; 9⅛–4–3⅞–13⅝; 8–3⅞–3½; 8–3¾–3⅝. ♀ 8¾–4⅛–3½–13; 8¾–4⅛–3½–13¼.

Family, Hirundinidæ.

41. **Progne dominicensis** (Gmel) "Hirondelle," Pat. and Fr. (Swallow).

A martin or large swallow was observed rather commonly about Roseau, but very rarely seen elsewhere. No specimens were taken, but it was undoubtedly the above species which was obtained by Mr. Ober.

Family, Vireonidæ.

42. **Vireo calidris** (Linn.). "Cheweck Tetlong," Pat. (Fr Tête longue, Long head).

Vireosylvia altiloqua (Vieill.); Tayl. List
Vireosylvia calidris var. *dominicana* Lawr.; Lawr List.
Vireosylvia calidris (Linn.); Scl. List.

Common and widely distributed. In habits and note resembling *V. olivaceus*. Very likely, as Mr. Ober thought, this bird is a summer visitor only, for our first specimen was not taken until March 27.

Sexes much alike. Iris generally brown, but in one specimen, a female, it was red; upper mandible dark horn, the lower bluish-white. ♂ $6\frac{1}{2}$–$3\frac{1}{4}$–$2\frac{1}{4}$–10; 7–$3\frac{1}{4}$–$2\frac{7}{16}$–10; $6\frac{1}{2}$–$3\frac{1}{8}$–$2\frac{5}{16}$. ♀ $6\frac{1}{4}$–3–2–$9\frac{3}{8}$; 6–$3\frac{1}{8}$–$2\frac{3}{16}$–9; $6\frac{3}{8}$–3–$2\frac{3}{16}$–$9\frac{3}{4}$. Exposed culmen in ♂ ·65, in ♀ ·60; tarsus in both sexes ·75.

Family, Cœrebidæ.

43. **Cœreba dominicana** (Taylor) "Sucrier," Pat. and Fr. (Sugarmaker)

Certhiola dominicana Taylor; Tayl., Lawr, and Scl. Lists.

Abundant almost everywhere. Sexes similar. One of the males (perhaps immature), differs from the others in having the anterior half of the superciliary line bright yellow, very little grey on the forehead, and the back greyish black instead of jet black as in the others. Bill black, legs and feet dark brown. They seem to vary much in size, the wings of the males ranging from $2\frac{1}{2}$–$2\frac{1}{8}$, the tails from $1\frac{3}{4}$–$1\frac{1}{4}$, the bills from ·53–·50 and the tarsi from ·74–·66. ♂ $4\frac{1}{2}$–$2\frac{1}{2}$–$1\frac{1}{2}$.

"Nest built almost anywhere, composed of a great variety of materials. Sometimes it is very beautiful and composed wholly of moss. Generally globular in shape with the opening on one side. Breeds continually from February to May."—(A. H. V.)

One nest in the collection was taken at Laudat, March 26th, and contained two slightly incubated eggs. It is globular in shape with the opening on one side and composed of leaves, grass, roots and stems. The mouth of the opening is lined with very fine rootlets

and stems. The total height of this nest is 5¾ in.; greatest diameter, from the bottom of the opening to back of nest outside, is 4¼ in. The opening is 1¼ in. high, 1 in. wide and situated 2½ in. from the bottom of the nest. (Plate xxv, fig. 3.) The eggs measure ·74×·52 and ·77×·52. The ground color is white very thickly and finely spotted with light chocolate-brown (in one so as to entirely obscure the white, except at the tip of the small end, which is clear white), heavier at the large end, where are a few fine lines of much darker brown.

Another nest is composed like the last, but with the outside beautifully covered with dark green moss like that in the nest of the "Morvy," (*Cichlherminia dominicensis*).

Another nest with four fresh eggs, taken April 10th, is composed like the first, but much smaller, measuring 3¼ in. in height and 3¾ in. from front to back. The opening is round, 1 in. in diameter, and is 1½ in. from the bottom of the nest. The eggs measured ·69×·51, ·70×·51, and ·71×·53, the fourth is badly broken. The first resembles the former set but with the large end darker, Plate xxv, fig. 9; the second has around the large end a much darker band which is clearly defined toward the small end, but gradually grows a little lighter at the extreme large end, the rest of the egg is not so thickly marked as in the former examples, Plate xxv, fig. 10; in the third the spots are much larger, the large end is very thickly marked and the rest of the egg not very thickly. The last egg, which has been so broken as to prevent measuring, closely resembles the set first described.

Two other sets measure as follows: one set ·71×·49; ·74×·51; ·76×·52 and the other ·70×·49; ·70×·51; ·73×·51.

The color and markings are much like those previously described.

Family, Mniotiltidæ.

44. **Dendroica petechia melanoptera** Lawr. "Teeteen," Pat.

D. petechia (Linn.); Tayl. and Lawr. List. Afterwards described by Lawrence as above (P. U. S. N. M., vol. i, p. 458).

D. melanoptera Sharpe; Scl. List.

Abundant in low, open woods, lime groves, and on the estates. Found low down, near the coast, as well as higher up in the mountains. Habits and notes much resemble *D. æstiva*. Sexes unlike in color. One female shows a faint trace of rufous on the crown and has a few light rufous streaks below. Irides dark brown, bill black, legs and feet light brown.

♂ 5–2⅜–1½–7; 5–2¼–2–7. ♀ 5–2⅜–1⅝–7; 5–2–1¾–7.

Several nests and sets of eggs are in the collection. Two characteristic ones, may be described as follows:

The first nest, taken on April 17, contained two fresh eggs, one $\cdot 64 \times \cdot 49$, white with very slight greenish tint, with a ring of small brown and grey confluent spots about the larger end, the rest of the egg sparingly spotted with the same colors, thickest at the large end, very lightly toward the small end, the brown predominating over the whole egg. The other egg is $\cdot 65 \times \cdot 50$, much like the other, but with the brown spots much larger, clearer, and of a deeper brown with no grey spots and fewer brown ones outside of the ring at the large end. Plate xxv, fig. 11.

The nest is compactly made of dry grass, stems of plants, leaves, chicken feathers, bits of cloth, colored wool, and several cocoons of spiders. It is lined with chicken feathers and horse hair, and measures $2\frac{1}{4}$ in. across the top and 2 in. high; the cavity is $1\frac{5}{8}$ in. across the top and $1\frac{1}{2}$ in. deep.

The other nest taken on April 9th contained three fresh eggs intermediate in color between the two just described and measuring $\cdot 65 \times \cdot 50$, $\cdot 64 \times \cdot 49$, and $\cdot 64 \times \cdot 50$. The nest is much like the last but composed of more dried grasses and quite a little cotton, and contains no chicken feathers nor bits of cloth. It is lined with horse hair and a little down from the silk cotton tree.

45. Dendroica plumbea Lawr "Pa-pia," Pat

PLATE XXVII, FIG. 2.

Very abundant, found nearly everywhere. Very tame and unsuspicious. Generally seen running up and down trunks of trees and hanging on the terminal twigs and leaves after the manner of the nuthatches and titmice.

Sexes alike. The green plumage described by Mr. Lawrence (Ann. N. Y. Acad. Sci., vol. i, 1879, p. 47), as that of the female is evidently the livery of the young as we took two females in the full grey plumage like that of the males, and one young female, April 14, with the grey feathers appearing on the top of the head, back of neck, around the bill, and on the throat, but otherwise agreeing with Mr. Lawrence's description of the female plumage, except that the line over the eye and the lower eyelid are both bright yellow instead of white as he describes them.

Iris dark brown; upper mandible dark horn-color; the lower yellowish, growing darker at the tip; legs and feet brownish yellow. ♂ $5\frac{1}{2}$–$2\frac{1}{2}$–2–8; $5\frac{3}{4}$–$2\frac{9}{16}$–$2\frac{5}{16}$–8, tarsus $\frac{13}{16}$. ♀ $5\frac{1}{2}$–$2\frac{7}{16}$–$2\frac{1}{8}$–$7\frac{3}{4}$; $5\frac{1}{2}$–$2\frac{3}{8}$–

$2\frac{1}{4}$; ♀ juv. $5\frac{1}{2}$–$2\frac{5}{8}$–$2\frac{1}{4}$. In all specimens the bill, from front, measures $\frac{7}{16}$, and the tarsus (except in one case), $\frac{3}{4}$.

"Nest very much like *Spinus tristis*, built in low shrubbery, particularly oleanders and grape plums. Eggs very much like *D petechia melanoptera*, but generally larger and more heavily marked. Laudat, April 1; Shawford, April 19."—A. H. V.

46. **Seiurus noveboracensis** (Gmel.)

A bird described by the natives as being there early in the season, was doubtless this species, which was taken by Mr. Ober and which probably occurs simply as a migrant.

47. **Setophaga ruticilla** (Linn.) "Officer Bird," Eng. "Chat," Eng.

Probably a migrant only, as none were seen after May 1st. Sexes unlike. Differs in no way from New England specimens.

♂ 5–$2\frac{1}{2}$–$2\frac{3}{8}$; ♀ 5–$2\frac{3}{8}$–$2\frac{1}{4}$.

Family, TROGLODYTIDÆ.

48. **Cinclocerthia ruficauda** (Gould). "Trembleur," Pat and Fr. "Trembler" (Eng)

Abundant and very widely distributed. Taken at every camp. Found chiefly in dense shrubbery near the ground, though frequently seen in the tops of tall trees searching for insects after the manner of the warblers and vireos. Towards evening it also ascends to the top of some bush or tree to sing, after the manner of the Brown Thrasher (*Harporhynchus rufus*), which it resembles in many of its habits and notes. Its name comes from its peculiar habit of constantly vibrating or "trembling" its wings, which are generally carried slightly raised from the sides and with the tips beneath the tail, which is also raised.

Sexes alike. Irides yellow, bill black, legs and feet brown. ♂ $9\frac{1}{2}$–$3\frac{3}{4}$–$3\frac{1}{4}$–$12\frac{1}{2}$; $9\frac{1}{4}$–$3\frac{7}{8}$–3–$12\frac{1}{4}$; 9–$3\frac{3}{4}$–$3\frac{1}{2}$–12 ; $9\frac{1}{2}$–$3\frac{3}{4}$–$3\frac{1}{2}$-12. ♀ 9–$3\frac{7}{8}$–$3\frac{1}{2}$.

"Nest closely resembles that of our Brown Thrush (*H. rufus*), but often built at a considerable distance from the ground. It is composed of fine twigs and grasses, generally with more or less mud. The eggs are said by the natives to be dark bluish green. All the nests found contained young. Breeds early, about the last of February."—(A. H., V) .

49. **Thryothorus rufescens** Lawr. "Rosingnole," Pat. (Fr Rossignol, Nightingale). "Nightingale," Eng.

PLATE XXVII, FIG. 1.

Rather common, but shy and difficult to procure. Found chiefly near the ground, generally in thickets and heavy undergrowth along

the borders of trails and openings. Its loud clear song is much oftener heard than the bird itself is seen, but by dint of quiet and patient waiting I have several times been able to observe its habits, which, together with its notes, resemble those of our House Wren (*Troglodytes aëdon*).

The male only, of this species, was described by Mr. Lawrence, as Mr. Ober did not take any females. We obtained two, and five males. The sexes do not differ but little, but the females are a shade lighter in color than the males, this being most noticeable on the throat and sides of the head and face. They also are slightly smaller than most of the males and the bill is very slightly shorter, about $\frac{1}{32}$ of an inch.

Two of the males vary from the rest; in one, taken March 8, at Laudat (the last one given in the list of measurements below), each feather of the under surface is lightly tipped with dark brown, strongest across the breast, wanting on the flanks. In the other specimen there is one white tertiary in the left wing, and on dissection the left testicle was found to be very rudimentary; whether there is any connection between the two facts I cannot say, but could find no traces of any injury.

Iris brown; upper mandible dark brown; the lower yellow, growing brown at the tip; legs and feet light brown. ♂ $5\frac{1}{4}$–2–$1\frac{5}{8}$–7; $5\frac{1}{4}$–2–$1\frac{1}{2}$–$6\frac{7}{8}$; 5–2–$1\frac{1}{4}$–$6\frac{1}{2}$; 5–$2\frac{1}{4}$–$1\frac{1}{2}$–$6\frac{1}{2}$; $4\frac{1}{2}$–2–$1\frac{1}{2}$. ♀ $4\frac{1}{2}$–$1\frac{3}{4}$–$1\frac{1}{2}$–$6\frac{1}{2}$; $4\frac{1}{2}$–2–$1\frac{7}{16}$. In all specimens, bill, from front, $\frac{9}{16}$, from rictus $\frac{3}{4}$, tarsus $\frac{11}{16}$.

"Nest built of sticks and roots in hollow logs, etc. Eggs generally two to six, very much like those of the 'Sucrier' (*C dominicana*) but generally smaller A nest with three eggs taken April 9th, 1890, at the Mountain Lake."—A H V.

The three eggs mentioned, measure ·74 × ·51, ·73 × ·51, ·59 × ·48, and do not differ appreciably in the color and markings from those of the "Sucrier."

Family, Turdidæ.

50. **Myadestes dominicanus** Stejn "Siffleur Montagne," Pat and Fr. "Mountain Whistler," Eng

Referred to *Myiadestes genibarbis* Sw in Lawr. List.

Common but, from its shy and retiring habits, much more often heard than seen. Generally found in deep, dark woods, at an elevation of at least 800–1000 feet and for the most part higher. Its shy and solitary habits, more than two individuals being rarely seen together, are apparently due to natural disposition rather than

timidity, for it permits quite a close approach without manifesting fear or attempting to escape. In its movements it is, for the most part, slow and deliberate, very different from most of the thrushes. Its note is perhaps its most striking characteristic, and once heard, coming from the depths of some dark ravine, the author being usually entirely invisible, can never be forgotten. It is a loud and clear but rather melancholy whistle, slowly uttered and repeated at intervals, the bird usually remaining in the same place for some little time.

Sexes much alike In most of our series of twelve specimens I can see no trace whatever of the olivaceous tint on the head, mentioned by Mr. Stejneger (Proc. U. S. Nat. Mus., vol. v, p. 22), and the same tint on the back does not seem to vary but very little with the sex, it being almost absent on some females, and quite plain on some males. Again, the olivaceous on the lores and over the eye seems to vary greatly, being decided in some, and almost absent in others, without regard to sex or season; so that I judge it, together with the tint on the back, to be more a matter of age or individual variation than a sexual or specific character, as the specimens that are strongest olivaceous on the back, have the most of the same tint on the lores and over the eye. In one, a female, taken May 15, where the tint on the back even approaches rufous and extends on to the wing coverts, the olivaceous on the head is very decided, the whole side of the head and some of the ear coverts being washed with it. Irides brown, legs and feet yellow, bill black ♂ $8\frac{5}{8}$–$3\frac{1}{4}$–$3\frac{7}{8}$–12 ; $8\frac{1}{2}$–$3\frac{1}{2}$–$3\frac{1}{2}$–$11\frac{1}{2}$; $8\frac{1}{4}$–$3\frac{3}{4}$–$3\frac{3}{4}$–$11\frac{1}{2}$. ♀ $8\frac{1}{4}$–$3\frac{1}{2}$–$3\frac{1}{2}$–$11\frac{3}{4}$; $8\frac{1}{4}$–$3\frac{5}{8}$–$3\frac{1}{2}$–$11\frac{5}{8}$; 8–$3\frac{5}{8}$–$3\frac{3}{4}$. One specimen, sex undetermined owing to mutilation, $7\frac{3}{4}$–$8\frac{3}{8}$–$3\frac{1}{2}$–$10\frac{1}{2}$.

"Nest a very frail structure of hair and roots, something like that of our Chipping Sparrow (*Spizella socialis*) Eggs, two in number, white, spotted with lilac about the larger end One nest taken with badly incubated eggs which could not be saved. Situated about 8 feet from the ground in a lime tree Laudat, April 9, 1890 '—(A H V)

51. **Allenia montana** (Lafr) "Grive," "Grivotte," Pat and Fr (Small Thrush)

Margarops montanus (Vieill); Lawr., and Scl List

Common but, like the following, much hunted and hence rather shy. Widely distributed and found in much the same places as the next species, though as a rule nearer the ground, sometimes close to or on it. Song like that of the "Grosse Grive" but shorter.

Sexes alike. Irides of adult, white or pale yellow; of the young brown; bill black; legs and feet dark brown. ♂ 9½–4¾–3⅞–14½; 9–4⅝–3½. ♀ 9–4½–3½. ♀ juv. 9½–4½–3¼–12½.

"Nest like that of the 'Grosse Grive' (*C. fuscata densirostris*) but smaller"—(A. H. V.)

One set taken, May 3, at Spring Hill, contained very large embryos. These eggs are of a uniform blue green color and measure 1·14 × ·78, 1·11 × ·80 and 1·23 × ·79.

52. **Cichlherminia fuscata densirostris** (Vieill.). "Grosse Grive," Pat. and Fr. (Large Thrush).

Margarops densirostris (Vieill.), Lawr. List.

Not common and very wild. This and the foregoing are much hunted for food, which probably accounts for their shyness. Well distributed and found mainly in the tops of trees and seen flying over at considerable height. The song of this and the preceding is loud and rather pleasing but short, somewhat like that of our Wood Thrush (*Turdus mustelinus*), and is mainly uttered late in the afternoon, a short time before sunset.

Sexes much alike, the male apparently slightly larger. Irides white; legs, feet, and upper mandible yellowish brown; lower mandible yellow at the base, dark at the tip. ♂ 12½–5½–4½, extent not taken. ♀ 11¾–5⅝–4½–17⅝.

"Nest built of twigs and lianas, closely resembling that of the Brown Thrush (*Harporhynchus rufus*). Eggs blue. Several nests found with young. Breeds in February March."—(A. H. V.)

53. **Cichlherminia dominicensis** (Lawr.). "Morvy," Pat. (Fr. Mauvis, Redwing).

Referred to *Margarops herminieri* (Lafr.) in Lawr. List. Afterwards described by him as *M. dominicensis* (P. U. S. N. M., vol. iii, p. 16).

Not common and very shy. Found chiefly near the ground in the thick woods, Laudat, Bass-en-ville.

Note, a loud whistle somewhat resembling some of the notes of the Blue Jay (*Cyanocitta cristata*).

Sexes much alike, the female appears to have rather more white on the abdomen. Irides white; legs, feet and bare skin surrounding eyes, yellow; upper mandible yellowish brown, darker at the base; lower mandible yellow. ♂ 10⅛–4⅞–3⅝–15⅝; 10¼–5–3½–16. ♀ 11–5–3¼; 11–5–3½; 11–4⅞–3.

One nest taken at Bass-en-ville, May 19th, contained only a few fragments of the eggs, of a beautiful, uniform blue green about the color of those of the "Grive" (*A. montana*). It was in thick,

swampy woods situated in the crotch of a small tree about ten feet from the ground and is a very handsome structure, composed mainly of long, dark green moss thickly lined with small roots and stems of plants. Diameter on top 5¼ in., on bottom 8 in., height 4 in. The cavity measures 3¾ in. across the top and 2½ in. deep. Plate xxv, fig. 4.

54. **Mimocichla verrillorum** Allen. "Perro-vanter," Pat

PLATE XXVII, FIG. 3.

M. ardesiaca (Vieill.)· Scl List.

M. ardesiaca albiventris; Scl. List. in notes (P. Z. S. 1889, p. 326).

M. albiventris (Scl); Allen in Auk, vol. viii , No. 3, p 217.

Very rare and shy. The only two specimens obtained, a pair, were taken at Lasswa, on the windward or eastern side of the island, and apparently, from the testimony of the natives and our own experience, its habitat is mainly confined to that portion of the island, though once or twice its notes were heard near Bass-en-ville, and, as mentioned later on, it was taken on the western side the previous year, by Mr. Ramage.

"Note a shrill, plaintive whistle."—(A. H. V.)

Sexes much alike, but the female "slightly smaller than the male, with the breast paler and the abdomen more deeply tinted with yellowish buff."—(Allen.) Bill, legs and feet yellow; iris dark brown. Measurements, from skin: ♂ length, 10·50; wing, 4·60; tail, 4·50; culmen, 0·85.

Mr. J. A. Allen described this bird under the above name in the "Auk" for April, 1891 (vol. viii., No. 2, p. 217), considering it a new species, but later, in the next number of the same journal (p. 317), refers it to *M. albiventris* (Scl.), adopting as specific the quasi sub-specific name used by Dr. P. L. Sclater in his "List of Birds Collected by Mr. Ramage in Dominica, West Indies" (P. Z. S., 1889, p. 326), in speaking of two male specimens collected by Mr. Geo. A Ramage at Batalie, on the leeward side of Dominica, in March, 1889.

In the enumerated list of Dominican birds at the head of his article, Dr. Sclater mentions the bird in question as *M. ardesiaca* (Vieill.) from which, as Mr. Allen has shown in his first article, it is quite distinct, but later on in the article he says, "as might have been expected the Dominican *Mimocichla* belongs to the Porto Rican form. It is, in fact, so nearly similiar that I do not see sufficient grounds for making it specifically distinct. The only difference apparent is the much greater whiteness of the belly in the

Dominican specimens whence, those who adopt trinomials, would, no doubt, call it *M. ardesiaca albiventris*." And again, a little further on, he alludes to it as *M. ardesiaca albiventris* but gives no further description, and failed, as Mr. Allen remarks in his second paper, to point out some of the principal differences between this and *M. ardesiaca* (Vieill.) From this and the fact that he calls it *M. ardesiaca* (Vieill.) in his enumerated list at the head of his article it hardly seems as though he intended to recognize it as a sub-species, and certainly not as a distinct species, which it is clearly shown to be by the following characters given by Mr. Allen in his first article "Similiar to *M ardosciacea* of San Domingo and Porto Rico, but much smaller, with much more white on the tail, and with the abdomen strong buff instead of plumbeous fading into white." * * * "This species finds its nearest relative in *Mimocichla ardosciacea* of Porto Rico and Santo Domingo holding somewhat the same relation to it as regards the color of the ventral surface that *M. rubripes* holds to *M. plumbea.* The wing and tail are each fully three-fourths of an inch shorter in *M. verrillorum* than in *M. ardosciacea;* the culmen is also shorter; but the tarsi are slightly longer and the wing appreciably more rounded. The white in the tail is much purer and twice greater in extent, tipping the outer five pairs of feathers instead of being confined to the outer four, as in the other species of the genus, and occupying considerably more than the apical half of the outer feathers."

Not taken by Mr. Ober, but probably the "5. Thrush?" mentioned by Mr. Lawrence (Proc. U. S. Nat. Mus. i., 1878, p. 58), as having been "described by several persons, something like the Thrush, but with yellow bill and legs." Nest and eggs not taken but said by the natives to resemble those of the "Trembleur" (*C. ruficauda.*)

Appended is a list, complete so far as I have been able to ascertain, of all the birds that have been recorded from Dominica. It contains all the species recorded by Mr. E. C. Taylor, who was there in 1863; Mr. Ober, who was there in 1877; Mr. Ramage, who was there in 1887 and 1888; and my brother and myself, who were there in 1890, and shows what species were recorded by each collector, and whether actually obtained or observed by him.

It is, I believe, the most complete list, so far published, of the birds of this island, but it is not yet complete, probably by quite a number of species, and it is, I think, quite probable that in some of the denser and more unexplored parts of the island there may yet be found birds entirely unexpected there, or even undescribed species.

	List of Birds recorded from Dominica.	By whom recorded: E. C. Taylor.	F. A. Ober.	G. A. Ramage.	G. E. and A. H. Verrill.
1	Sterna dougalli Montag	--	+	-	-
2	Sterna antillarum (Less.)	-	+	--	-
3	Sterna fuliginosa Gmel.	-	+ 1	--	?
4	Sterna anæthetus Scop.	--	+	-	--
5	Anous stolidus (Linn.)	--	?		--
6	Phaethon flavirostris Brandt	-	+	--	×
7	Pelecanus fuscus Linn	×	×	-	×
8	Fregata aquila (Linn.)	×	×	--	×
9	Ardea herodias Linn.	-	--	--	×
10	Ardea egretta Gmel	--	--	--	×
11	Ardea candidissima Gmel	-	+	-	(?)
12	Ardea cærulea Linn.	--	+ 1	--	(?)
13	Ardea virescens Linn.	+	+	+	+
14	Nycticorax violaceus (Linn.)	-		+	+
15	Ionornis martinica (Linn)		+ 1	--	(?)
16	Ereunetes pusillus (Linn.)	--	?	--	?
17	Actitis macularia (Linn)	--	+	-	×
18	Charadrius dominicus Müll.	-	×	--	
19	Arenaria interpres (Linn.)	--	+ 1	--	-
20	Columba corensis Gmel.	+ 1	+	--	+
21	Columba leucocephala Linn	--	--	--	×
22	Zenaida martinicana Bonap.	+	+	+	+
23	Columbigallina passerina (Linn.)		+	+	+
24	Geotrygon montana (Linn.)	--	+	--	+
25	Geotrygon mystacea (Temm.)	--	--	--	×
26	Buteo latissimus (Wils.)	-	+	+	+
27	Falco columbarius Linn.	--	--	--	+
28	Falco caribbæarum Gmel.	×	+	+	+ ♂
29	Pandion haliaëtus carolinensis (Gmel.)	--	×	--	×
30	Strix flammea nigrescens Lawr.	--	+	--	+ ♂
31	Amazona augusta (Vig.)	--	+	+	+
32	Amazona bouqueti (Wagl.)	--	?	+	+ ♀
33	Coccyzus minor (Gmel.)	+	+	+	+
34	Ceryle alcyon (Linn)	--	×	--	×
35	Cypseloides niger (Gmel.)	--	?	--	+
36	Chætura dominicana Lawr.	--	+	--	+
37	Eulampis jugularis (Linn.)	+	+	+	+
38	Eulampis holosericeus (Linn.)	+	+	+	+
39	Thalurania bicolor (Gmel.)	--	+	+	+
40	Bellona exilis (Gmel.)	+	+	+	+
41	Tyrannus rostratus Scl.	--	+	+	+
42	Myiarchus tyrannulus oberi (Lawr.)	+	+	+	+
43	Blacicus brunneicapillus Lawr.	-	+	+	+
44	Elænea pagana martinica (Linn.)	+	+	+	+
45	Loxigilla noctis sclateri Allen.	+	+	+	+
46	Euethcia bicolor (Linn.)	+	+	+	+
47	Euphonia flavifrons (Sparrm.)	-	+ ♀	--	+
48	Saltator guadelupensis Lafr.	+	+	+	+
49	Progne dominicensis (Gmel.)	--	+	--	?
50	Vireo calidris (Linn.)	+	+	+	+
51	Cœreba dominicana (Taylor)	+	+	+	+
52	Dendroica petechia melanoptera Lawr.	+	+	+	+

	List of Birds recorded from Dominica.	By whom recorded. E. C. Taylor.	F. A. Ober.	G. A. Ramage.	G. E. and A. H. Verrill.
53	Dendroica plumbea Lawr.	..	+	+	+
54	Dendroica virens (Gmel.)	..	+ 1	..	.
55	Seiurus noveboracensis (Gmel.)	.	+	..	(?)
56	Setophaga ruticilla (Linn.)	..	+	+	+
57	Cinclocerthia ruficauda (Gld.)	..	+	+	+
58	Thryothorus rufescens Lawr.	..	+ ♂	+	+
59	Myadestes dominicanus Stejn.	..	+	+	+
60	Allenia montana (Lafr.)	.	+	+	+
61	Cichlherminia fuscata densirostris (Vieill.)	..	+	.	+
62	Cichlherminia dominicensis (Lawr.)	..	+ ♂	..	+
63	Mimocichla verrillorum Allen	..	(?)	+ ♂	+

The following signs are used in the above table: + = actually obtained; × = observed and species identified but not obtained; ?= observed and probably of that species but not positively identified; (?)= described by the inhabitants and probably of that species but not seen by the collectors themselves; + ♂ or + ♀ indicates that the sex indicated only was obtained. In several cases only one specimen was taken by the former collectors but the sex is not mentioned by them in their lists, in such cases it is indicated thus, + 1.

To this list should be added *Tringa minutilla* Vieill. taken in Dominica by Dr. Nicholls, and sent to the Smithsonian in 1880. He also sent ten other species, all of them included in the above list; but the three following, though they were observed, have not been actually taken there by any of the above collectors.

Anous stolidus.
Ereunetes pusillus.
Charadrius dominicus.

List of Batrachians and Reptiles obtained.

BATRACHIA.

Order, ANURA.

Family, Cystignathidæ.

1. **Leptodactylus pentadactylus** Lawr. "Crapaud," Pat. and Fr. (Toad.)

Common and much used for food. When used for the table the whole animal is eaten, generally as a stew, and not simply the legs, as is the case with frogs in this country. Prepared in this way it makes a delicious dish, tasting much like chicken, but more delicate.

2. **Hylodes martinicensis** D. and B. Tree Toad.

Rather common. All our specimens were taken at a considerable elevation (1000–2000 feet), and were found under stones or logs.

REPTILIA.

Order, OPHIDIA.

Family, TYPHLOPIDÆ.

3. **Typhlops lumbricalis** Linn "Blind Worm"

Apparently rare. We only obtained one specimen and no others were seen.

Family, BOIDÆ.

4. **Boa diviniloquax** Daud "Boa."

Rather common. Our specimens were all obtained in the interior, near Bass-en-ville, and apparently it is found mainly in the densely wooded and elevated parts of the island. This species sometimes attains large size. We heard of their being taken 12 or 13 feet long, but none of our specimens were over 7 or 8 feet in length. Three were brought to New Haven alive.

Family, COLUBRIDÆ.

5. **Opheomorphus juliae** Cope. "Snake."

Not particularly common. This, the preceding species, and the "Blind Worm" were the only snakes found by us on the island, though Mr. Ober took a fourth, *Alsophis sibonius* Cope. This species varies much in color and general appearance so that the natives, and we ourselves, thought there were several species among them. In one specimen, the largest, 21 inches long, the round yellow spots near the base of the scales, spoken of by Mr. Cope, are entirely lacking.

Order, LACERTILIA.

Family, GECKONIDÆ.

6. **Sphærodactylus oxyrhinus** Gosse. Gecko.

One specimen only obtained, at Bass-en-ville, and no others were observed.

Family, IGUANIDÆ.

7. **Iguana delicatissima** Lawr. "Iguana."

Rather common. Frequently used as food. My brother states that the flesh is very fair eating.

8. **Anolis leachii** Gray. "Chameleon"

Very abundant and widely distributed. Found at all elevations. A very lively and beautiful species. A peculiarity of this lizard is the effect upon it of whistling or music, causing it to stop and listen attentively and even allow itself to be caught

Family, TEIIDÆ.

9. **Amiva plei** D. and B, var. **brachiosquamatus**, nov Cope. "Arbalo' (Pat.)

Prof. E. D. Cope describes this new sub-species as follows. "Differs from typical forms in having numerous rows of small brachial scales as in *A. major*, instead of one large row as in typical *A. plei*. Three supraorbital plates. Otherwise as in *A. plei*."

Very abundant in the lowlands, particularly in the cane-fields, where on a hot, sunny day they may be seen by hundreds They are exceedingly quick in their motions and run with great rapidity, so that they can only be procured by shooting. This species grows very large, frequently attaining a length of two or three feet.

I think there are at least two species of "Arbalos," but we only succeeded in obtaining one.

Family, SCINCIDÆ.

10. **Mabuia agilis nigropunctata** Spix Skink

Common, but shy and difficult to catch. Generally found in rather damp places and at quite an elevation.

Order, CHELONIA.

Family, TESTUDINIDÆ.

11. **Testudo tabulata** Linn Turtle

Our specimen came from the island of Tortola, but we were told that they were also found in Dominica, though rare.

Species obtained by Mr. Fred. A. Ober, in addition to the above List.

Mr. Ober obtained four species of reptiles (no batrachians), in Dominica, which are described by Prof. E. D. Cope in the Proc. Amer. Philos. Soc., vol. xviii, p. 274.

Of these four species one was also obtained by us, *Opheomorphus juliæ*, the others I give below to complete so far as possible, the herpetology of this island, though I feel sure the list of species is still far from complete, especially among the lizards.

12. (1.) **Mabuia cepedei** Gray.

13. (2.) **Xiphosurus oculatus** Cope.

14. (3.) **Alsophis sibonius** Cope.

List of Land and Fresh-water Crustacea obtained.

1. **Palæmon jamaicensis** Oliv. "Crawfish." Prawn.

Common in the fresh-water streams and extensively used as food, being of excellent flavor.

One or more species of small grey shrimp were frequently seen in the river at Bass en-ville, but owing to their very lively habits and our lack of proper means we were unable to procure any.

2. **Cenobita diogenes** Latr. "Sojer" (Soldier). Hermit Crab.

Not very common.

"Found only on the windward or Atlantic side of the island"– (A. H. V.)

3. **Gecarcinus ruricola** Latr. "Crabe," Pat. and Fr. (Crab) Land Crab.

Common, but not found among the mountains nor at any great elevation. Very good eating and much used for food.

4. **Pseudotelphusa dentata** (H. Milne-Edw.) "Surique," Pat. Land Crab.

Pseudotelphusa tenuipes. R. I Pocock (Ann and Mag Nat. Hist., vol iii, p 7, 1889)

Very common in the interior and among the mountains. We found this species extremely abundant in the neighborhood of Bass-en-ville. They were seen running around everywhere in the woods, though also found along the shores of the streams and in the streams themselves, but apparently it made no difference whether water was near or not, though of course the ground is everywhere very damp from the frequent rains. When disturbed or pursued they run very rapidly and generally get into some hole or under a log or stone, but I could never see that they had any particular hole or burrow. When unable to reach some such shelter they sit back on the hind part of the carapax, after the manner of our common Fiddler Crab, and defend themselves savagely. By throwing out a piece of meat a number could always be brought around the camp in a very short time.

Though not usually sold in the market, like the former species, and not considered so good eating, they are by no means bad, as I can testify from personal experience, and they are frequently eaten by the natives up among the mountains.

Mr. R. I. Pocock in the Ann. and Mag., vol. iii, p. 6, 1889, has recorded an additional species of land crab (*G. lateralis*), and several additional species of shrimp and prawns collected in Dominica by Mr. Ramage.

Notes on the Insects.

The collection of insects has not yet been worked up and so no list of the species can be given.

We found the Coleoptera and Lepidoptera quite abundant, the other orders much less so.

Our collection contains about twenty species of beetles, some of which are very interesting, to an ordinary observer at least, on account of their difference from New England forms.

Probably the most striking is the Hercules Beetle. These enormous beetles are quite rare and found mainly among the mountains. According to the inhabitants there are several species, but we procured but one, dark brown with greenish grey wing coverts, spotted with black. According to my brother, they feed on the locust and cocobolo trees, and he also says that on the windward side of the island this species is replaced by another that is still larger and entirely brown.

Another large brown "horn-bug" has a big white larva, called in Patois "Gru Gru Worm" which lives in the buds of the palm trees, and which is roasted and eaten by the natives.

The "fire-beetles" of this island are of several species, very numerous, and exceedingly brilliant, the light being constant and coming from the body under the wing coverts and from two round spots on the side of the thorax. They are a kind of snapping-beetle, dark brown, and about an inch long. A few of them flying about a room make enough light to distinguish large objects, and two or three in a small bottle give light enough, when held near the page, to read ordinary print. They are found mainly in the interior. At Bassen-ville they were very abundant.

We also took a number of large yellow and black weevils which were found on the plantain and banana plants.

The name "La Belle" is applied by the natives to all beetles.

Several large green katydids, called by the inhabitants "Crak Crak," were also taken, and enormous cockroaches, or "Drummers," were very abundant, especially in the houses.

We also found a few mole-crickets and a walking-stick but they were both rare.

No true scorpions were seen but a large whip-scorpion was obtained and also several large myriapods or centipedes.

The collection of Land Mollusca, consisting of about twenty species, several of them probably new, is now in the hands of Mr. H. A. Pilsbry of Philadelphia, for working up. As soon as this is done a list will be published.

EXPLANATION OF PLATES.

PLATE XXV.

Fig. 1. Nest and female of *Eulampis jugularis*, "Fou Fou Mardet," ½ natural size. p. 331.

Fig. 2. Cup-shaped nest and eggs of *Eulampis holosericeus*, "Fou Fou Tête-longue," ½ natural size. p. 332.

Fig. 3. Nest of *Cœreba dominicana*, "Sucrier," ⅝ natural size. p. 341.

Fig. 4. Nest of *Cichlherminia dominicensis*, "Morvy," $\frac{3}{10}$ natural size. p. 347.

Figs. 5 and 6. Eggs of *Blacicus brunneicapillus*, "Gobe-mouche," natural size. p. 337.

Figs. 7 and 8. Eggs of *Elænea pagana martinica*, "Cheweck," natural size. p. 337.

Figs. 9 and 10. Eggs of *Cœreba dominicana*, "Sucrier," natural size. p. 341.

Fig. 11. Egg of *Dendroica petechia melanoptera*, "Teeteen," natural size. p. 342.

PLATE XXVI.

Figs. 1 and 2. Nests of *Eulampis holosericeus*, "Fou Fou Tête-longue," natural size. p. 332.

Fig. 3 Nest of *Bellona exilis*, "Fou Fou Bequar," natural size. p. 335.

Figs. 4 and 5. Nests of *Thalurania bicolor*, "Fou Fou Bleu," natural size. pp 334 and 333.

Fig. 6. Nest of *Bellona exilis* "Fou Fou Bequar," natural size. p. 334.

PLATE XXVII.

Fig. 1. *Thryothorus rufescens*, "Rosignole," adult male, ⅝ natural size. p 343.

Fig. 2. *Dendroica plumbea*, "Pa-pia," adult female, ⅝ natural size. p. 342.

Fig. 3. *Mimocichla verrillorum*, "Perro-vantor," adult female, ⅓ natural size. p. 347.

The above photo-lithographic plates, by Mr. E. Crisand, of New Haven, are made directly from photographs of the original specimens.

NOTE.—Since the previous pages were printed I find that in preparing my list of the Reptiles and Batrachians, I unfortunately overlooked an article by Dr. A. Günther (Ann. and Mag. Nat. Hist (6), II, p. 362), on the collection made by Mr. Ramage, and one by Mr. Samuel Garman (Bull. Ess. Inst, XIX, p. 1), on the collections in the Museum of Comparative Zoology, at Cambridge.

Dr. Günther enumerates ten species, of which two, *Thecadactylus rapicauda* (Houtt.) and *Ameiva fuscata* Garman (l. c. p 5), are additional to my list, though the latter is probably the other "Arbalo" seen, but not obtained, by us. *Sphærodactylus copii* (Steind.), also recorded by him, is possibly the same as our *S. oxyrhinus* Gosse. In this paper Dr. Günther unites *Xiphosurus oculatus* Cope with *Anolis alliaceus* Cope, and *Mabuia dominicana* Garman with *M. agilis* (Radde), of these, the two former are doubtless the same as our *A. leachii* Gray, and the two latter identical with our *M. agilis nigropunctata* Spix.

ERRATUM.—Page 350, fifth line from bottom, and page 351, third line from bottom, for "Lawr." read "Laur."

XX.—On a Collection of Land Mollusca from the Island of Dominica, West Indies. By Henry A. Pilsbry.

Collections of the land mollusks of Dominica have been made by Mr. R. Lechmere Guppy,* Mr. A. D. Brown,† Mr. G. F. Angas,‡ Mr. G. A. Ramage§ and Dr. Benj. Sharp.‖ The present list is based upon a collection made in March, April and May, 1890, by Messrs. G. E. and A. H. Verrill.¶

In Mr. E. A. Smith's reports upon the collections made by Mr. Ramage, a full list of the land molluscan fauna of the island is compiled from the reports of previous investigators. To that paper, therefore, the student is referred for references to the literature of the fauna.

HELICIDÆ.

Helix (Dentellaria) nigrescens Wood (11845).**

A color variety (11854) is yellowish-olive, becoming brown toward the lip and in front of the aperture.

H. (Dentellaria) badia Fér. (11826)

H. (Dentellaria) josephinæ Fér (11844, 11829).

BULIMULIDÆ.

Bulimulus laticinctus Guppy. (11846)

This is no doubt a local variety of the five-banded *B. multifasciatus*, in which two of the bands are confluent, the band formula being 1(23)45, whilst that of typical *multifasciatus* is 12345.

* See Guppy's report in Annals and Magazine of Nat Hist (4), I, p 429, 1868.

† American Naturalist, 1881, p. 56 Mr Brown's specimens are now in the collection of the Academy of Natural Sciences of Philadelphia.

‡ Proc. Zool. Soc, 1883, p 594

§ See E A. Smith's reports in Ann. and Mag N H (6) II, p. 227, 419.

‖ The specimens collected by Dr Sharp are in the collection of the Academy of Natural Sciences of Philadelphia

¶ This collection is in the Museum of Yale College

** The figures refer to the museum numbers of the Yale College collection.

B. exilis Gmel. (11827, 11856, 11851, 11855, 11847).

The following color-forms are represented:

(1) Horn colored, bandless (11827).
(2) Horn colored, having a faint peripheral band (11847, 11851)
(3) Horn colored, having a conspicuous dark band (11856).
(4) Having three dark purple-brown bands, the upper and lower bands wider (11855).

B. nichollsii A. D. Brown (11850, 11848, 11849)

A species peculiar to Dominica.

Amphibulima patula Brug. (11828, 11835).

STENOGYRIDÆ.

Stenogyra octona Chemn (11852, 11840).

VAGINULIDÆ.

Vaginula punctatissima Semper. (11830)

Not before reported from Dominica. The black blotches of the ventral surface are much more conspicuous than one would suppose from Semper's figure.

HELICINIDÆ.

Helicina rhodostoma Gray. (11842, 11853, 11841).

The usual variations in lip coloring, from yellow to deep red, are represented.

H. epistilia Guppy. (11839).

A single specimen may be referred to this unfigured and rare species.

H. velutina Guppy. (11837, 11838).

The specimens are a trifle more depressed than *H. rufa* Pfr. from Yuma, Haiti, but the difference is so slight that I am wholly disposed to consider Guppy's species a synonym of the earlier described Haitian form. Pfeiffer's description of *H. rufa* is imperfect, as the delicate *velvety* character of the cuticle is not noticed by him. I have, however, compared specimens from Yuma with the Dominican shells, and am satisfied that they are identical.

NERITIDÆ.

Neritina punctulata Lam. (11825).

The specimens were collected from the Layou River at Bass-en-Ville, at an altitude of about 2000 ft. They are large, and have the mouth-callus of a dull reddish color.

CYCLOPHORIDÆ.

Cyclophorus (Amphicyclotus) amethystinus Guppy. (11843)

There can be no doubt that this species is distinct from *C. schrammi*, although the young greatly resemble the latter. It is known only from Dominica.

NOTE. — In the above article it will be seen that Mr. Pilsbry makes but fourteen species and none of them are new, several specimens which had been supposed, in a hasty examination, to be different species proving to be only color varieties of the other described forms.

The small number of species obtained by us was doubtless due to the fact that our collections, as stated at the beginning of my article, were made almost exclusively at a considerable elevation (from 1000 to 2500 feet), and no doubt mainly above the range of many species such as *Succinea approximans*, *Amphibulima rubescens*, *Leptinaria lamellata*, *Helix dentiens*, *Helicina fasciata*, *H. antillarum*, etc.

A large part of the Mollusca were collected in the vicinity of Bass-en-ville, at about 2000 feet elevation, and in the midst of the deep woods, which may also account for the absence of some species that frequent the gardens and plantations.

Here we found *Helicina rhodostoma* abundant on the trunks of trees and old stumps about our camp.

The Layou River flowed past our camp at this point, and in it *Neritina punctulata* was exceedingly abundant. All the specimens we saw, and we examined hundreds, were marked by cavities, varying much in size but often very deep and wide, which had the appearance of having been drilled or bored out. In many cases these holes covered the whole shell, but I think we never found any that had penetrated entirely through it.

Stenogyra octona was very abundant under logs and stones in the vicinity of all our camps.

Vaginula punctatissima was not common, but we found several specimens under logs and stones in the vicinity of Spring Hill.

Bulimulus laticinctus was found rather commonly near Laudat on the plantain and banana plants.

In Mr. E. A. Smith's articles, mentioned above by Mr. Pilsbry, there are enumerated thirty-four species of land mollusks inhabiting Dominica; of these a few seem to be of doubtful identity, or hardly entitled to specific rank, but there are probably over thirty good species now known from this island.—G. E. VERRILL.

XXI.—New England Spiders of the Family Thomisidæ.

By J. H. Emerton.

Thomisidæ.

In the *Thomisidæ* the cephalothorax and abdomen are both flattened. The cephalothorax is about as wide as long, and the abdomen is usually widest behind. The legs are turned outward and forward more than downward, so that the body is carried close to the ground, and some species walk more readily sidewise than forward.

The family consists of two groups or sub-families, the *Thomisinæ* and the *Philodrominæ*.

In the *Thomisinæ* the first and second pairs of legs are about equal in length and much longer than the third and fourth. The feet have two claws and under them a small cluster of hairs like the rest of the hairs on the leg.

In the *Philodrominæ* the legs are more nearly equal in length, all long and slender, and the second pair usually longest. The feet have two claws and under them a large cluster of long hairs, widened and flat at the end.

The eyes of the *Thomisidæ* are small and nearly of the same size and have a simple arrangement in two rows. The maxillæ are short and narrow at the ends. The males usually differ considerably in size and color from the females, and in some species the males are very much smaller than the females.

The *Thomisidæ* live mostly on plants, and in winter hide in cracks and under stones and bark. Their colors resemble the plants on which they live, most species being marked with gray and brown like bark, while those living on flowers are brightly colored, white and yellow. They make no webs and no nests except a few threads to hold the cocoon and conceal it by drawing together a leaf over it.

A large part of the New England species have been described, a few of them by Hentz in the Journal of the Boston Soc. Nat. Hist., vol. v, but more by E. Keyserling in the Proceedings of the zool. botan. gesellschaft of Vienna and in a separate book on the "Spinnen Americas, Laterigradæ," published in 1880. The spiders in the Museum of Comparative Zoology at Cambridge have been named by Keyserling and among them are several of the New England species which have been compared with my own specimens.

While this paper was printing, Mr. Nathan Banks published in the Proc. Acad. Nat. Sci of Philadelphia, a Catalogue of the spiders

of the upper Cayuga Lake basin (Ithaca, N Y.), with descriptions of many new species. Mr. Banks has let me examine his spiders and his names have been used for several species.

Xysticus.

The body is short and flat. The cephalothorax is as wide as long, nearly square in front and half as wide across the eyes as it is at the widest part.

The front row of eyes is almost straight and the four middle eyes form a square or a rectangle wider than long.

The abdomen is not much larger than the cephalothorax, widest across the hinder half and not pointed behind. The legs are short in the females, the first and second pairs nearly equal and longer than the third and fourth which are also of nearly the same length. The males have the legs longer and the first and second pairs proportionally longer than the females.

The males are a little smaller than the females and darker colored The male palpi are short. The tibia has a short simple process on the outer side and a crooked and more complicated one underneath The tube of the palpal organ begins on the inner side of the tarsus and extends around the bulb to the outer side where it rests in a small thin process turned outward. On the under side of the bulb are two processes of various shapes in different species.

The epigynum has a rounded opening variable in shape even in the same species, sometimes simple and sometimes divided by a median ridge.

Xysticus limbatus Keys Spinnen Americas, 1880

The female *X. crudelis* Banks and *X. brunneus* Banks, appear to be this species, but the male *X limbatus* Banks is different from my *X limbatus* and nearer the male *X limbatus* Keyserling

PLATE XXVIII, FIGURES 1 1*h*.

This is one of the largest species, the females measuring 8 or 10^{mm} long and the cephalothorax 4^{mm} wide.

The colors are light brown spots of various shades on a nearly white ground, some individuals being very pale and others nearly covered by the brown spots. In half grown individuals the markings are most distinct and are like those of Hentz's figure of *Thomisus ferox* which is very likely this species, Pl. XXVIII, fig 1*b*. In these the sides of the thorax are light brown and the abdomen has on each side three or four nearly square brown spots darkest on the

front and outer edges. The middle of the cephalothorax has a light marking tapering behind to the dorsal groove which is marked by a dark spot. The legs have a distinct fine light line on the dorsal side and are marked all over with small light brown spots without any distinct bands or patches except that the fourth femur and tibia are darker at the ends. In the adults the markings are less distinct and that of the middle of the cephalothorax darker so as to obscure the lateral stripes. Pl. XXVIII, figs. 1, 1*a*. The males have the same markings but darker. Fig. 1*a*. The epigynum, figs. 1*d*, 1*e*, 1*f*, has a simple opening of various shapes, sometimes with a low and indistinct ridge through the middle. The male palpus has a large and complicated hook under the tibia turned a little toward the outer side so as to be visible from above. Fig. 1*h*. The processes of the bulb are large and dark colored, the under one pointed and directed inward, and the other wide at the end and turned backward to the base of the bulb. Fig. 1*g*.

Males from Medford and Peabody, Mass. Females, Dedham, Peabody, Cambridge, Malden, Salem, Mass; Simsbury, Conn. Both sexes from Brooklyn, Long Island, N. Y., N. Pike. A female with cocoon partly covered by a folded leaf was found June 10.

The specimens in the Museum Comp. Zool. at Cambridge, named by Keyserling, are all females. The male which I suppose to belong to this species is not the *limbatus* Keys., but probably *X. elegans* Keys.

Xysticus gulosus Keys

♂ = *X. locuples* Keys., Spinnen Americas, 1880, and *X. lentus* Banks

PLATE XXVIII, FIGURES 2–2*c*.

The female is 6 to 8^{mm} long with the cephalothorax 3^{mm} wide. The color is grayish brown and very uniform, the usual marking showing indistinctly among the fine brown spots that nearly cover the body. The femora are light on the ventral side and have two or three large spots along the middle. The femora are darker toward the end, those of the fourth pair having a distinct black spot near the end. The abdomen has usually only a pair of irregular black lines across near the middle, and several smaller and less distinct behind it. Pl. XXVIII, figs. 2, 2*a*.

The epigynum has an oval opening wider than long, in which are two oval ridges directed backward. Fig. 2*c*.

The male palpus has the under tibial process wide and turned outward at the end. The tube of the palpal organ is unusually long and

slender and has a long outward curve at the tip and a long thin process to support it. Fig. 2*b*.

Salem and Beverly, Mass., under stones; Long Island, N. Y., N. Pike.

Xysticus stomachosus Keys, Spinnen Americas, 1880

A small female apparently of this species is named *X. benefactor* in the Mus Comp. Zool. Cambridge.

PLATE XXVIII, FIGURES 3–3*d*

This is a little smaller than *limbatus*. A mature female measures 6^{mm} long and the thorax 3^{mm} wide. The largest males are as large as small males of *limbatus*. The brown markings are grayer than in *limbatus* and less evenly distributed over the body. The lateral dark bands of the cephalothorax are very distinct and have a darker line on the outer edge and two darker spots behind under the front of the abdomen. The middle of the cephalothorax is light, but a little darker toward the front of the head.

The brown markings of the abdomen are light with black spots along the front and outer edges of each marking. The first and second legs are covered with small brown spots darker and closer at the ends of the joints. The third and fourth legs are lighter and have darker spots at the ends of the joints, the fourth legs having conspicuous dark spots on the ends of patella and tibia. Pl. XXVIII, figs. 3, 3*a*.

The epigynum has a wider opening than *limbatus*, divided by a flat ridge at the hinder edge. Fig. 3*d*.

The male palpus has the under process of the tibia small and divided at the end into two blunt knobs. The tube is stout and black and ends between two large thin processes on the outer side. Pl. XXVIII, figs. 3*b*, 3*c*. The processes of the bulb are small but extend outward from its surface. The anterior process is attached near its middle and pointed at both ends. Figs. 3*b*, 3*c*.

Readville, Brookline, Saugus, Swampscott, Mass.; New Haven, Conn.; Long Island, N. Y., N. Pike's collection.

Xysticus nervosus Banks.

PLATE XXVIII, FIGURES 4–4*d*.

Female 6^{mm} long, and cephalothorax 3^{mm} wide. The markings of both sexes are very indistinct and much alike. The general color is light brownish yellow with darker and lighter markings scattered in

small spots all over the body. The middle of the cephalothorax is as usual light colored with a few brown markings in the middle and toward the eyes. The sides of the cephalothorax are darker with irregular brownish lines. The abdomen has three or four pairs of indistinct brown spots, in front of which and on the front of the abdomen are irregular small white spots. The legs are marked in the same way with irregular light and dark spots, the first and second pairs a little darker than the others. Pl. XXVIII, figs. 4, 4*a*.

In the males the first and second legs are very long and slender, the second twice as long as the third pair. The markings are a little brighter and more distinct than in the female. The under process of the tibia of the male palpus is curved and turned outward at the end as in *gulosus*. The processes of the bulb are long and the anterior one has a complicated twist at the end. Figs. 4*c*, 4*d*, 4*e*.

The epigynum has a large oval opening, widest behind, in which are two smaller openings divided by a narrow ridge, fig. 4*b*.

Medford, Readville, Mass.; Long Island, N. Y., N. Pike.

Xysticus triguttatus Keys., Spinnen Americas, 1880

The spider named *X. ferocius* by Keyserling in the Museum of Comp. Zoology, Cambridge, is the female of this species and so is *X. ferocius* Banks.

PLATE XXIX, FIGURES 1–1*d*

The female is 5 or 6^{mm} long and the cephalothorax 2^{mm}. The legs of the female are white or yellowish with a few black hairs and small spots around the ends of the femora. The cephalothorax is yellowish brown with a line of black marks each side ending in a distinct black spot at the hinder end. The third black spot is just behind the dorsal groove. The middle of the cephalothorax is very light behind and darker toward the front and middle of the head, Pl. XXIX, fig. 1, and the area between the eyes is white. The abdomen is white with two small black spots in front and several lines of black spots broken in the middle across the hinder half.

The male is as large as the female and much darker in color. The markings of the cephalothorax are like those of the female, but darker. The femora of the first and second legs are dark brown and the rest of the legs dull yellow. The tarsus of the male palpus is white and the rest dark. The abdomen has very dark markings, those of the hinder half usually running entirely across, with white between. Fig. 1*a*.

The epigynum has a large shallow oval opening, in the middle of which is a small hole with a hard projecting ridge each side. Fig. 1*c*.

The male palpus has the tube stout and extending almost entirely around it. The processes of the bulb are small and the posterior one blunt and notched at the end. Fig. 1*d*.

This is a very common species in grass and low plants all over New England. In Psyche, vol. v, I have described the pairing of this species. The female held herself on a blade of grass, head downward, with the abdomen turned away far enough for the male to reach under, from above, to the epigynum.

Xysticus graminis, new sp

PLATE XXIX, FIGURES 2–2*b*

This species resembles in color and markings the male of *X. triguttatus*. It is a little larger and darker, and there is less contrast between the light and dark portions. The legs are shorter and stouter and the patella and tibia of the first and second legs, as well as the femur, are dark brown. The ends of these legs, as well as the third and fourth pairs, are light yellow brown, not as white as in *triguttatus*. The dark bands on the cephalothorax are not so distinctly broken into black marks as in *triguttatus*, nor are the three spots as distinct. The markings of the abdomen do not extend across the front half and the lighter parts are not as white as in *triguttatus*. Pl. XXIX, fig. 2.

The male palpus resembles that of *triguttatus*, but the processes of the bulb are longer and both pointed and directed inward. Fig. 2*a*.

The female is 6^{mm} long and the cephalothorax is 3^{mm} long and 3^{mm} wide. The legs are short and stout. The color is dark brown with very small light markings. The front of the head is wide and light colored, with a distinct white band under the upper row of eyes, behind which is a very dark brown line. The dark patches on the sides of the thorax are partly divided into two, the inner halves ending in darker spots, as in *triguttatus* and *stomachosus*, but less distinctly marked. In the middle of the cephalothorax is a triangular dark area narrowing to a dark spot behind, and each side of this a light line narrowing forward to the eyes. The abdomen is dark with alternate narrow darker and white markings across the hinder half and obliquely down the sides. The legs are covered with small brown spots. The first and second femora are lighter on the front side, and the third and fourth legs have a light line on the dorsal side. The femora of the third and fourth legs have a dark spot at the end. The under side is dark with small brown spots, and the

spinnerets and epigynum are each covered by a very dark round spot. The epigynum resembles that of *triguttatus*.

Males from Peabody and Saugus, Mass. Females, Brookline, Mass., S. Henshaw.

Xysticus formosus Banks.

PLATE XXIX, FIGURES 3, 3*a*.

The male is 5^{mm} long and the cephalothorax $2{\cdot}5^{mm}$ wide. The dark sides of the cephalothorax extend toward the middle behind the eyes so that the middle light portion is narrower than usual. The parts around the eyes are white and so is the back of the cephalothorax around the dorsal groove. The hinder ends of the dark bands are nearly black where they pass under the front part of the abdomen. The abdomen is white in the middle with irregular brown spots, and the sides are dark brown, in angular patches that do not extend as far toward the middle as usual. The legs are covered with irregular brown spots and the patella and tibia of the first and second legs are much darker than the rest. Pl. XXIX, fig. 2.

The tibia of the male palpus has a very small hook underneath, but the outer process is longer than usual and between it and the inferior process is a wide flat tooth. Fig. 2*a*. The palpal organ is very simple, the usual processes of the bulb being represented only by a very short flat ridge. Fig. 2*a*.

Only one male from West Roxbury, Mass.

Xysticus quadrilineatus Keys, Spinnen Americas, 1880

PLATE XXIX, FIGURES 4, 4*a*

Female 7^{mm} long. Cephalothorax $2{\cdot}5^{mm}$ wide. In this species the cephalothorax is unusually wide in front. The color is light yellow with light brown markings and black spots. The cephalothorax has four narrow brown stripes, one each side close to the edge, and the others running back from the lateral eyes. There are also two fine brown lines in the middle, sometimes extending from the eyes to the dorsal groove, but usually broken in the middle. There is a brown spot just behind the dorsal groove and two others on the middle of the back, half way between the groove and the middle eyes. On the abdomen there are two black spots at the front end, two in the middle and two near the hinder end, besides several smaller ones along the sides. There are four light brown lines across the hinder half, each with a white line behind it, and there are oblique brown lines alternating with white at the sides. Pl. XXIX, fig. 4. The

legs have the usual light line along the dorsal side and are covered with fine brown spots without any distinct markings. The epigynum has an oblong opening, widest behind. Fig. 4*a*.

Medford, Swampscott, Beverly, Mass.; Long Island, N. Y., N. Pike.

Xysticus inornatus, new sp

PLATE XXIX, FIGURES 5–5*b*

The adult female is 5^{mm} long, with the cephalothorax 2^{mm} wide. It is less flattened than most species and has the cephalothorax rounded up in the middle, where it is much higher than the eyes. Pl. XXIX, fig. 5. The cephalothorax is dark brown, almost black, with a lighter line in the middle and a white line each side near the edge. The legs are colored in the same way, but the thin parts between the joints are white. The tarsi of all the legs are lighter than the rest At the base of the first and second femora, in front, are white spots, and the third and fourth legs have white longitudinal stripes. The under side of the cephalothorax and legs are of the same color, with white joints. The abdomen is light gray with indistinct lighter lines at the sides and small light spots in the middle. Pl. XXIX, fig 5. The epigynum has a small opening, with two wide anterior and two sharp posterior projections from its edges. Fig. 5*b*

Two young specimens less than half as large, have all the dark portions light yellowish brown.

Adult from Medford, Mass.; young from Beverly, Mass., and New Haven, Conn.

Oxyptila Simon, 1864

This genus differs little from *Xysticus*. The cephalothorax is flatter in the middle and the head narrower. The middle eyes of both rows are nearer together so that they form a rectangle longer than wide. The middle eyes of the front row and usually of both rows are farther forward than in *Xysticus*, so that both rows of eyes are more curved. There is less difference between the length of the front and hind legs in the males than in *Xysticus*. The dark markings of the thorax often approach each other behind, as in our species.

Oxyptila cinerea, new sp.

PLATE XXIX, FIGURES 6, 6*a*.

This male is $4{\cdot}5^{mm}$ long and the cephalothorax $2{\cdot}5^{mm}$ long and 2^{mm} wide. The colors are grayish brown and white. The light portion

of the cephalothorax is narrowed near the dorsal groove and widened in front a little behind the eyes. Pl. XXIX, fig. 6. The abdomen has the usual markings, all indistinct. The legs are marked more nearly alike than in the other species. The femora are all thickly spotted with brown, and the third and fourth have a large dark spot at the end. The other joints are all light with dark rings at the ends. The inferior process of the tibia of the male palpus is large, rounded at the base, and turned outward at the tip. Pl. XXIX, fig. 6*a*. The processes of the bulb are small and both turned inward at the points. The tarsus is curved downward a little at the end.

One male, only, from the White Mountains, New Hampshire.

Coriarachne Thorell.

The cephalothorax and abdomen are both very much flattened, not more than half as high in proportion to their width as in *Xysticus*. The cephalothorax is flat on the top, not rounded up from the middle, as in *Xysticus*. The head is narrower and more distinctly separated from the thorax by depressions at the sides. The arrangement of the eyes is the same as in *Xysticus*, except that the two rows are nearer together and lower. The male palpus has a small thin tooth on the end of the outer process of the tibia and there are no appendages to the under side of the bulb as there are in *Xysticus*.

Coriarachne versicolor Keys., Spinnen Americas, Laterigradæ, 1880.

PLATE XXIX, FIGURES 7–7*a*.

The female is 5 or 6^{mm} long with the cephalothorax 2·5^{mm} wide. The colors are black and gray on a white or yellowish ground, in irregular spots that vary in size in different individuals. There is usually a dark spot in the middle of the cephalothorax in front of the dorsal groove, and behind the eyes are four spots more or less run together and connected with smaller spots behind them. Along the sides of the thorax are four pairs of spots, the hinder pair largest. In the male these spots all connect together and the cephalothorax is often nearly black. The legs are covered with small dark spots and have larger spots near the ends of the joints and along the middle of the femur. In the male the femur, patella and tibia of the first and second legs are much darker than the other joints. Pl. XXIX, figs. 7, 7*a*.

The epigynum has the opening a long distance from the transverse fold and divided into two by a ridge that widens backward, Pl. XXIX, fig. 7*c*, much like the epigynum of *C. depressa*, of Europe.

The tibia of the male palpus has a large inferior process slightly bent inward at the end. The outer process is longer and the slender tip is on the inner side and s-shaped. Fig. 7*d*. The tube of the palpal organ is stout and has in the middle a thick portion, roughened like a file. The end of the tube is straight, not spiral as in *C. depressa*.

All over New England, on fences and under stones.

Misumena vatia Thorell = *Thomisus fartus* Hentz.

Adult females of this and of *aleatorius* are both named *vatia* by Keyserling

PLATE XXX, FIGURES 1–1*g*.

The female of this species is the largest and best known of the genus. It is 8 or 10^{mm} long and milk white, with sometimes a light crimson marking on each side of the abdomen. Pl. xxx, fig. 1. The cephalothorax is wide and high in front, the distance between the upper lateral eyes being twice their height. Fig. 1*b*. The sides of the cephalothorax are very light yellow or brownish, the dark color being most distinct in young spiders. The dark markings also extend between the eyes and around the sides of the head, but the front of the head has a white mark that widens below over the mandibles and above under the eyes and around the eyes of the upper row. This marking of the front of the head, Pl. xxx, fig. 1*b*, distinguishes this species from *aleatoria*.

The legs are white with light brown on the upper side of the first and second; or even this is absent in some individuals.

The epigynum has a deep rounded notch in the middle, the corners of which are prolonged backward over the spermathecæ. Each side of the large notch are two small ones. Pl. xxx, fig. 1*g*.

The male is only 3 or 4^{mm} long, with the front legs about twice the length of the body. The males are strongly marked with dark reddish brown on a light ground. The cephalothorax is dark at the sides, while the front of the head around the eyes is white, as in the female. The abdomen has a dark stripe at the sides extending, sometimes, its whole length, or in other individuals not more than half as far. In the middle of the abdomen are two parallel dark marks or lines of spots, figs. 1*d*, 1*e*. The first and second legs have the femur dark brown, the patella dark on the outer half. The tibia dark at both ends, and the tarsus and metatarsus on the outer half. The palpi are light with the palpal organ brown. The third and fourth legs are light.

The male palpi are small. The tarsi are short and nearly as wide as long. The tibial process is smaller than in the other species and

has the litte hook on the end. Pl. xxx, fig. 1*f*. The bulb is round at the base and has a shallow notch at the distal end, over which is the short and small tube, twisted once at the end.

The young male has the form of the female with part of the markings of the male. The femora and palpi are light colored. Pl. xxx, fig. 1*e*.

The female and male from Menge's collection of Prussian spiders in the Museum of Zoology at Cambridge, are exactly like American specimens, except that the female has the hairs on the legs a little more distinct and the epigynum has the lateral openings larger and the middle one proportionally smaller.

Common all over New England, as far north as the White Mountains.

Misumena aleatoria = *Thomisus aleatorius* Hentz = *Runcinia Brendelii* Keys.

Adult females are named by Keyserling *M. vatia* and young females *Runcinia brendelii* in the Museum of Comp. Zoology at Cambridge.

PLATE XXX, FIGURES 2–2*d*

The female of this species, Pl. xxx, fig. 2, is easily mistaken for *vatia*. It is smaller, the color is more yellow, from light straw color to orange, and it does not have the crimson stripes on the abdomen, though it occasionally has dark reddish brown marks in the same places and a double row of dark spots in the middle of the back. Pl. xxx, fig. 2*e*. The cephalothorax is light yellow or greenish, with the sides a little darkened with brown. The legs are usually yellow without markings, but sometimes, especially in individuals with spots on the abdomen, there are dark marks on the coxa and trochanter, patella, tibia, and metatarsus of the first and second legs. The front of the head is lower than in the other species and the distance between the upper lateral eyes is nearly three times their height. Below the eyes is a white stripe the lower corners of which are extended into lines over the mandibles and the upper corners into a very distinct white line that extends under the eyes and around the sides of the head. Pl. xxx, figs. 2*a*, 2*b*.

The epigynum (fig. 2*b*) has the notch less deep than in *vatia* and more open behind.

The male is only 3^{mm} long, but with the first and second legs 8^{mm} in length. The cephalothorax is much like that of the female, green with the sides dark brown. The abdomen is bright yellow. The first and second legs are dark brown without any markings, and the

palpi are brown but not quite as dark. The third and fourth legs are light yellow. The immature males have the front legs no longer than those of the female and only partly colored brown. Pl. xxx, fig. 2*d*.

The young of both sexes have the abdomen darker in the middle, with light stripes in the hinder half.

The male palpi, Pl. xxx, figs. 2*f*, 2*g*, are very small. The tibial process extends half the length of the tarsus and has a sharp point turned a little outward and just below the point a small hook turned upward. The palpal organ is much smaller than the tarsus, flat and circular with a short tube and without any other processes.

The abdomen of the female is a little flatter than that of *vatia*, straighter at the sides and more truncated behind.

Massachusetts and Connecticut.

Misumena asperata = *Thomisus asperatus* Hentz

Misumena georgiana Keyserling, specimen in Mus Comp Zool, Cambridge; and *M. johata* Banks

PLATE XXX, FIGURES 3–3*e*.

This species does not grow as large as *vatia* and the color of the adult female is more generally yellow, sometimes deep yellow, but oftener pale and greenish. The legs are a little spotted with pale brown and more hairy than in *vatia*. The males and young are brightly colored with dull yellow and reddish brown markings, some of which are retained by the female until the last moult. A female half grown (Pl. xxx, fig. 3*a*) has the cephalothorax light in the middle with a brownish stripe each side covering half way to the edge. The abdomen has a dark red band on each side of the front half and in the middle a pattern in light brick red. The first and second legs are marked with dark red-brown spots on the end of the patella, both ends of tibia, and the end half of the metatarsus. The hairs are much longer than in the adult.

A female just before the last moult had lost entirely the markings of the legs (Pl. xxx, fig. 3*a*), and had the pale markings of the adult behind the eyes, while the abdomen showed the two side stripes broken into several spots and three pairs of spots on the hinder half darkest on the outer side, all brick red. This spider was perched on a plant of sorrel (*Rumex acetocella*) and its colors were exactly those of the flowers. The male has the colors of the young, but all deeper, the ground yellow or greenish and the mark-

ings dark reddish brown. The femora of legs one and two are spotted with dark red, thickest toward the front (fig. 3*b*).

The epigynum has a wide oval opening divided into two round smaller ones by a wide ridge on which is a thin raised line in the middle (fig. 3*c*).

The male palpus has a large complicated process on the outer side at the end of which is a small black point, hooked at the end. The tube of the palpal organ is wide and curved once around the end of the bulb (Pl. xxx, figs. 3*d*, 3*e*), ending on the outer side. The male palpus is much longer than that of *vatia* and more than twice as large as that of *aleatoria*.

The abdomen of the adult female has often gray or reddish markings along the sides or in the middle.

Misumena oblonga Keys, Spinnen Americas, 1880

PLATE XXX, FIGURES 4–4c

Male 2·5mm long. Front legs 8mm long and very slender. Colors, in alcohol, greenish yellow on the cephalothorax and legs and white on the abdomen and around the eyes, with dark red markings. The front of the head is high, the distance between the upper lateral eyes being twice their height, as in *M. vatia*, but it does not have the white mark in front like that species. The eyes are all slightly raised on whitish tubercles. Pl. xxx, fig. 4.

The sides of the cephalothorax are slightly darkened and around its edge is a fine red line, short in some and in others extending its whole length, and there are also, in one specimen, red lines across the ends of the mandibles. The first and second legs have a short red ring at the end of the femur and the patella. The tibia has the distal half red and also a short ring at the base. The metatarsus is red for three-fourths its length, and the tarsus half its length. There are also a few red spots on the front of the first femur and at the ends of patella and tibia of fourth leg, but these spots are absent in one specimen. The cephalothorax, abdomen, and femora have stiff black hairs, standing wide apart.

The male palpi are as small as those of *aleatoria*, but shorter and more pointed, like those of *vatia*. The outer process of the tibia is much like that of *vatia*, but shorter and thicker, and the hook is placed more on the outer side. The tube is longer and straighter and more slender than in *vatia*. Pl. xxx, fig. 4.

The only female that seems to belong to this species is an immature specimen 4·5mm long. The color is pale yellow, darkened a

little at the sides of the cephalothorax and the ends of the legs. On the first and second legs there is a small dull red spot near the end of the tibia and a longer one on the metatarsus. The whole body is covered with long hairs arranged in rows. On the back of the abdomen there are about twenty rows of them nearly their length apart. On the legs they are in longitudinal rows a little nearer together. On the cephalothorax there is a middle row directed forward and another each side of it passing between the eyes. The other hairs of the cephalothorax point toward the middle. The body is smooth underneath, or with only very short hairs.

Males from Blue Hills, Milton, Mass.; New Haven and Simsbury, Conn.; young female from Brookline, Mass.; Washington, D. C., Dr. Fox.

Philodromus.

Cephalothorax as wide as long, rounded at the sides and much narrowed in front as far back as the base of the palpi. The front row of eyes is much shorter than the upper row. The legs are long and slender, the second pair longest. The third and fourth legs are not much shorter than the first and second. The hinder legs are wide apart and the sternum extends backward between them. The feet have the claws turned backward and under them a thick bunch of long hairs, wide and flattened at the end. The abdomen is longer than wide and a little pointed behind. The males are but little smaller than the females and much longer legged.

The male palpi have two processes on the tibia, the usual hard hooked process on the outer side, and a flat, thinner one underneath.

Philodromus vulgaris is a common and distinct species. The others are all small and much alike, especially the males, and the difference between the sexes is so great that it is difficult to tell the male and female of the same species, and the males which are referred to *ornatus* and *lineatus* may prove to belong to other species.

Philodromus vulgaris Keys. = *Thomisus vulgaris* Hentz

P. vulgaris Banks *P. praelustris* and *P. signifer* Banks are probably of this species

PLATE XXXI, FIGURES 1–1*g*.

Female, 8^{mm} long. Cephalothorax, 3^{mm} long and the same wide. Head less than half as wide as the middle of the cephalothorax. The abdomen is half longer than the cephalothorax and nearly as wide at the widest part. The colors are various shades of gray,

resembling closely those of old unpainted wood. The ground color is dirty white and the under side is almost entirely of this color. The dark portion of the back of the abdomen is darkest at the edges and does not entirely cover the abdomen, showing a lighter band around it, plainest around the hinder half. The principal middle markings are a long oval spot in front, pointed before and behind, and a herring-bone pattern behind. The legs are spotted with fine spots closest along the front of the femora and largest at the ends of each joint. Pl. XXXI, fig. 1. The males are darker and longer legged, as in most species, fig. 1*a*. The epigynum has two openings, between which is a ridge that widens behind and extends to the transverse fold. Usually this ridge has waved or irregular sides, as in fig. 1*f*, but in some the sides are rounded. Fig. 1*g*.

The male palpus is long with the tibia nearly twice as long as wide. The lateral process is as wide as long, square at the end, with the upper corner slightly hooked. The under process is smaller, rounded on the inner corner, and sharp pointed on the outer. Pl. XXXI, fig. 1*c*. The tarsus is twice as long as wide and pointed at the end. The tube is short and very thick at the base. It starts on the middle of the inner side of the bulb and extends around the end. Under the tip of the tube is a short fine process. Fig. 1*d*.

All over New England on houses and fences, but seldom on plants.

Philodromus pictus, new sp.—*P. rufus* (Walck.) Banks.

PLATE XXXI, FIGURES 2–2*e*.

Female 5 or 6^{mm} long. Abdomen usually about twice as long as the cephalothorax. The widest part farther forward than in most species. Legs and palpi pale yellow with fine brown spots Cephalothorax light yellow in the middle and reddish brown at the sides, covered with fine spots. Abdomen dull red at the sides and bright yellow in the middle with a dark greenish marking in the middle of the front half and two dark marks behind it on the hinder half. Pl. XXXI, fig. 2. The eyes are surrounded by distinct light rings. In some specimens, usually immature, the abdomen has a more distinct yellow and red pattern. Fig. 2*a*.

The male has the cephalothorax and legs darker and the abdomen less bright red and yellow than the female, and sometimes gray and iridescent. In alcohol it shows a more distinct herring-bone pattern on the hinder half. Fig. 2*b*.

The male palpus has the tibia nearly as long as the tarsus. The lateral process is unusually long and the upper corner has a sharp

hook. Fig. 2*g*. The under process is very thin and about as long as the lateral. The tarsus is widened on the inner side and the tube is long and slender, starting near the base of the bulb. The eyes are close in both sexes. Figs. 2*c*, 2*d*, 2*e*.

A very common species all over New England.

Philodromus ornatus Banks

=*P minusculus* Banks and *P placidus* Banks

PLATE XXXI, FIGURES 3–3*b*

The female of this species is small and very distinctly marked with dark brown on a white ground. The middle of the cephalothorax is white and the sides brown nearly to the edge. The abdomen is white with a distinct brown band each side from the front more than half its length. Pl. XXXI, fig. 3. Sometimes there is also an indistinct brownish pattern in the middle, but this is usually absent in adults and the middle is entirely white. The coxæ are brown and the rest of the legs white, except a little brown at the ends of the joints. Under the abdomen the lateral brown bands extend backward and meet across the spinnerets. The abdomen is nearly as wide as long and widest across the hinder half.

The male which I suppose belongs to this species has the legs and cephalothorax orange brown, darker at the sides of the thorax and toward the ends of the legs. The abdomen is dark reddish-brown, strongly iridescent with red and green in a bright light. In alcohol it shows brown markings at the sides similar to those of the female, and also indistinct angular marks in the middle of the hinder half. The palpi are long, but the tibia is little longer than wide and narrower than the patella The outer process is small and the under process wide and long, extending over the bulb a third its length. Pl. XXXI, figs. 3*a*, 3*b*. The tarsus is widest across the middle and straight on the outer side. The tube is very long and slender beginning at the base of the bulb near the under tibial process. Fig. 3*a*.

All parts of New England; Ithaca, N. Y., Banks.

Philodromus lineatus, new sp.

PLATE XXXI, FIGURES 4–4*c*.

The female of this species is a little larger than *ornatus* and the brown markings are lighter, and in life, or when freshly killed, purplish in the lighter parts. The markings are less distinct than in *ornatus*, the brown and white running into each other. The abdo-

men has a brown band each side, often broken into several spots, and a brown band in the middle extending back half its length, behind which are several lighter marks Between these are many oblique lighter markings and rows of spots. The legs are very light grayish brown, darker toward the ends of the joints. Pl. xxxi, fig. 4. The upper middle eyes are farther apart than in *ornatus*.

The supposed male of this species resembles closely the last, but is a little larger and has much larger palpal organs. The tibia is longer than wide. The outer process is very short and pointed obliquely outward. The under process is long and wide. Fig. 4*b*. The tarsus is nearly as wide as long, and the palpal organ nearly round. The tube begins on the outer side beyond the end of the under process and extends around the inner side and outer end. Fig. 4*c*.

All over New England. Not found by Banks at Ithaca, N. Y.

Philodromus bidentatus, new sp.

Plate XXXI, figures 5–5*b*

Of this species I have only males, one from New Haven, Conn., and two from Mt. Tom, in the central part of Massachusetts. They are 3^{mm} long and in their general appearance agree with the other species. The New Haven specimen is pale and has the markings very distinct, while the others are dark orange brown, like most male *Philodromus*, after a long time in alcohol. The markings of the legs are more in irregular patches of gray and less in fine spots than in most species, and the dark middle line of the cephalothorax is unusually distinct. The abdomen has the usual markings. Fig. 5. The male palpi have the tibia shorter than the patella and widened at the distal end. The lateral process is stout and has two teeth at the end. Pl. xxxi, fig. 5*b*. The under process is longer, but small compared with other species. Fig. 5*a*. The tube is shorter than in *pictus*, beginning near the middle of the side of the bulb.

Philodromus brevis, new sp.

Plate XXXII, figures 2–2*d*.

Males, $2{\cdot}5^{mm}$ long. The color of both specimens is dark. The cephalothorax does not have the usual light area in the middle, but only a lighter spot just in front of the dorsal groove. The rest of the cephalothorax is nearly uniform in color. Fig. 2.

The male palpi have the tibia short and straight, not widened at the ends. The lateral hook is long and stout and slightly curved

down at the end. Fig. 2*d*. The inferior process is short and wide. The tarsus is short and blunt. The tube is very short, not half the length of the tarsus, and nearly straight. Pl. XXXII, fig. 2*c*.

Two males only, from Readville, Mass.

Philodromus robustus, new sp.

PLATE XXXII, FIGURES 1–1*a*.

Male, 4^{mm} long. Legs and palpi stouter and more hairy than in the other species, and the mandibles longer. The specimen is much faded and there are no traces of markings on the legs. The abdomen shows the usual markings and the cephalothorax had the middle light colored with a dark line, widening toward the head.

The palpi have the tibia longer than wide and about as long as the patella. The outer process is slender and short, turned obliquely outward and blunt at the tip. Fig. 1*a*. The under process is thin but hard and as wide as long. The tarsus is as wide as long and the palpal organ nearly round. The tube is slender and extends half way around the bulb.

Beverly, Mass.

Tmarus E Simon, 1864

Cephalothorax widest across the middle, farther forward than in most of the family. Front of the head and mandibles inclined far enough forward to be seen from above. Lateral eyes of both rows on large round tubercles. Middle eyes forming a quadrangle longer than wide and widest behind. Abdomen longer than wide, widest across the hinder half and high, and pointed behind with the point in some species prolonged into a tubercule of various shapes.

Tmarus caudatus Keys = *Thomisus caudatus* Hentz.

PLATE XXXII, FIGURES 3–3*d*.

Female, 6^{mm} long. Cephalothorax, 2^{mm} long and as wide at the widest part. The abdomen is as narrow as the cephalothorax in front and widens backward to nearly twice that width. Fig. 3. The abdomen rises from the front to a point over the spinnerets, where it forms a blunt conical point. Fig. 3*a*. The first and second legs are nearly equal and much longer than the third and fourth. The mandibles are inclined forward, their basal half is nearly straight and the ends narrowed. The colors are gray and white, resembling light individuals of *Philodromus vulgaris*. The legs are

spotted with a few black dots, largest and closest on the front pair. The markings of the cephalothorax radiate indistinctly from the dorsal groove. The abdomen is covered with fine gray spots and has three or four pairs of darker lines across the hinder half. Pl. XXXII, fig. 3.

The males differ little from the females except in the smaller abdomen.

The male palpus has a short and blunt lateral process widened in the middle and thin and sharp at the end. Figs. 3*b*, 3*c*. The tarsus is wide and the palpal organ round and without any processes in the middle. The tube is slender, passing almost entirely around the bulb and supported at the end by a soft appendage with a hard sharp point. Figs. 3*b*, 3*c*. The epigynum has a small semicircular opening. Fig. 3*d*.

A common species in Massachusetts and Connecticut.

Ebo Keyserling, 1883

These spiders have a general resemblance to *Philodromus*. The whole body is flattened and wider than in that genus, the head is more rounded and the two rows of eyes more nearly of the same length. The legs of the second pair are much longer than the others.

Ebo latithorax Keys Zool bot ges, Wien, 1883

PLATE XXXII, FIGURES 4–4*d*

In this species the second pair of legs is more than twice as long as either of the others and has the claws of these legs much smaller than the others. The cephalothorax is wider than long and much flattened. The head is rounded in front. The mandibles are small and turned backward under the head. The eyes are arranged as in *Philodromus*, but there is less difference between the length of the two rows and the front middle eyes are larger than the others. Pl. XXXII, figs. 4*b*, 4*c*, 4*d*. The abdomen is as wide as long and a little pointed behind. Figs. 4, 4*a*.

The length is 2 to 2·5^{mm}. The color is light yellow with brownish markings on the cephalothorax and abdomen. On the cephalothorax are several radiating lines of spots running from the dorsal groove to the legs, and three shorter lines extending forward half way to the eyes. The abdomen has two dark spots at the sides in front and a line in the middle and an indistinct herring-bone pattern on the hinder half.

There is little difference between the male and female. The male palpus is slender and the palpal organ small. The tibia is twice as long as wide and has a short process on the outer side. The tarsus is slightly widened across the middle and the palpal organ is oval, about twice as long as wide. The tube is short and curved in a half circle across the end of the bulb. Figs. 4*e*, 4*f*.

Medford, Mass.; Providence, R. I.; Long Island, N. Y., in N. Pike's collection. The only males I have seen are in the latter collection.

Tibellus Simon, 1875.

Cephalothorax longer than wide. Abdomen very long and slender, narrower than the cephalothorax, and straight at the sides. Legs slender with long spines, second pair longest, and the fourth nearly as long as the first. Eyes on the top of the head. Both rows curved and the front row about half as long as the upper. The femur and patella of the female palpi a little thickened.

Tibellus duttonii Keys = *Thomisus duttonii* Hentz

Plate XXXII, figures 5–5*c*

Female, 8 or 10^{mm} long, the abdomen variable in length and thickness. The color is light yellow with light brown markings. The cephalothorax has a middle brown stripe and one on each side, all indistinct. The abdomen has two black spots on the hinder half and a light brown middle spot at the front end extending back half the length of the abdomen and ending in a point, or sometimes continuing the whole length. The abdomen is a little pointed behind and extends back far enough to cover the spinnerets. Pl. xxxii, fig. 5.

The male is a little more slender than the female. The male palpus is bent downward. The patella and tibia are both short and the tibia shorter on the under side than above, so that the tarsus joins it obliquely. Fig. 5*a*. The tibial process is short and blunt. The tube is stout and black and twisted at the tip and has beside it a flat process of about its own length. Fig. 5*b*. I have not been able to find the spider whose palpus was figured by me on plate 20 of the reprint of Hentz's spiders of the United States in 1875. All that I have seen since have the slender portion of the tube longer, as here figured. The epigynum is very far forward and has its opening behind over the transverse fold. Fig. 5*c*.

Massachusetts; common in the White Mountains and Northern New York.

Thanatus C Koch.

Cephalothorax as wide as long in males and almost as wide in females, resembling that of *Micrommata* and *Dolomedes*. The front row of eyes is much shorter than the upper row and both rows are curved. Pl. xxxii, fig. 6. The abdomen is oval and little flattened, but not as long and slender as in *Tibellus*. The fourth legs are as long as the second or longer, which is unusual in this family.

Thanatus lycosoides, new sp

Plate XXXII, figures 6–6c

This species is very near *T. coloradensis* Keys., and may be the same. It is smaller than the spiders described by Keyserling in both sexes, but the proportions are the same, and the male palpi almost like those of *coloradensis*, being a little more slender and having a sharper tibial process. Keyserling's specimens were all from Colorado and I have not seen any of them.

The female is 6 to 8^{mm} long. Cephalothorax of largest specimen, 4^{mm} long and nearly as wide. Length of legs, 4, 2, 1, 3. The legs are slender and tapering, the fourth pair as long as the second or longer. The colors are white and brown covered with brown and gray scales and scattered brown hairs, and the whole appearance is much like *Lycosa* or *Dolomedes*. The middle of the cephalothorax is light from the eyes backward, and on each side is a dark brown band. The abdomen has a distinct brown spot extending from the front end beyond the middle, and pointed at both ends. This spot is found in several species of the genus The legs are indistinctly marked on the femur and tibia with longitudinal brown lines. Pl. xxxii, fig. 6. The epigynum is close to the transverse fold and is divided by a flat ridge, widest in front. The openings are long and narrow and covered by a convex brown shell, each side opening widest toward the transverse fold. Fig. 6c.

The male is, as usual, smaller and longer legged and resembles more *Ocyale* and *Philodromus*. The male palpus is somewhat like that of *duttonii*, but shorter and stouter, and it has a longer and larger tibial hook. The palpal organ is large and extends beyond the tarsus on the outer side. The tube is short and slender and a little curved. Over the tube is a small, flat, soft appendage. Figs. 6*a*, 6*b*.

Wenham, Annisquam, Dedham, Mass.; and Mt. Carmel, Hamden, Conn.

EXPLANATION OF PLATES.

Plate XXVIII

Figure 1.—*Xysticus limbatus* Keys., female, × 4; 1*a*, male, × 4; 1*b*, young female with more distinct markings; 1*c*, maxillæ and labium; 1*d*, 1*e*, 1*f*, opening of epigynum of three different spiders; 1*g*, male palpus; 1*h*, tibia of male palpus from above.

Figure 2.—*Xysticus gulosus* Keys., female, × 4; 2*a*, male, × 4; 2*b*, male palpus; 2*c*, epigynum.

Figure 3.—*Xysticus stomachosus* Keys., female, × 4; 3*a*, male, × 4; 3*b*, 3*c*, male palpus; 3*d*, epigynum.

Figure 4.—*Xysticus nervosus*, female, × 4; 4*a*, male, × 4; 4*b*, epigynum; 4*c*, tarsus and tibia of male palpus; 4*d*, under side of male palpus.

Plate XXIX

Figure 1.—*Xysticus triguttatus* Keys., female, × 4; 1*a*, male, × 4; 1*b*, front of head of female; 1*c*, epigynum; 1*d*, male palpus.

Figure 2.—*Xysticus graminis*, male, × 4; 2*a*, male palpus; 2*b*, dorsal markings of female, × 4.

Figure 3.—*Xysticus formosus*, male, × 4; 3*a*, male palpus.

Figure 4.—*Xysticus quadrilineatus* Keys., female, × 4; 4*a*, epigynum.

Figure 5.—*Xysticus inornatus*, female, × 4; 5*a*, front of head of female; 5*b*, epigynum.

Figure 6.—*Oxyptila cinerea*, male, × 4; 6*a*, male palpus.

Figure 7.—*Coriarachne versicolor*, female, × 4; 7*a*, male, × 4; 7*b*, front of head of female; 7*c*, epigynum; 7*d*, male palpus.

Plate XXX

Figure 1.—*Misumena vatia* Thor., female, × 4; 1*a*, cephalothorax, enlarged; 1*b*, front of head; 1*c*, young male, × 4; 1*d*, 1*e*, adult males of different sizes, × 4; 1*f*, male palpus; 1*g*, epigynum.

Figure 2.—*Misumena aleatoria*, female, × 4; 2*a*, front of head; 2*b*, top of head; 2*c*, male, × 4; 2*d*, young male, × 4; 2*e*, young female with dark markings, × 4, from one in the collection of the Boston Soc. Nat. Hist.; 2*f*, 2*g*, male palpus; 2*h*, epigynum.

Figure 3.—*Misumena asperata*, female, × 4; 3*a*, young female, × 4; 3*b*, male, × 4; 3*c*, epigynum; 3*d*, male palpus; 3*e*, side of male palpus, less enlarged.

Figure 4.—*Misumena oblonga* Keys., male, × 4; 4*a*, 4*b*, male palpus; 4*c*, young female, × 4.

Plate XXXI.

Figure 1.—*Philodromus vulgaris* Keys., female, × 4; 1*a*, male, × 4; 1*b*, first foot, outer side; 1*c*, first foot, inner side; 1*d*, male palpus; 1*e*, tibia of male palpus, outer side; 1*f*, usual form of epigynum; 1*g*, epigynum of a female from Providence, R. I.

Figure 2.—*Philodromus pictus*, female, × 4; 2*a*, dorsal markings of a younger female; 2*b*, male, × 4; 2*c*, front of head of female; 2*d*, top of head of male; 2*e*, front of head of male; 2*f*, 2*g*, male palpus.

Figure 3 —*Philodromus ornatus*, female, × 4, 3*a* 3*b*, male palpus, 3*c* tibia of male palpus from above 3*d*, epigynum

Figure 4 —*Philodromus lineatus* female, × 4, 4*a*, sternum, 4*b*, side of male palpus, 4*c* male palpus, under side

Figure 5 —*Philodromus bidentatus*, dorsal markings of light colored male enlarged eight times, 5*a*, 5*b*, male palpus

PLATE XXXII

Figure 1 —*Philodromus robustus*, palpus of male, 1*a*, outer side of tibia of male palpus

Figure 2 —*Philodromus brevis* markings of cephalothorax of male × 8 2*a*, top of head, 2*b* front of head, 2*c*, 2*d*, male palpus

Figure 3 —*Tmarus caudatus* Keys, female × 4, 3*a*, side of abdomen of female 3*b*, 3*c* male palpus 3*d*, epigynum

Figure 4 —*Ebo latithorax* Keys, female, × 4, 4*a* male × 4, from a specimen in N Pike's collection of Long Island spiders 4*b* 4*c*, 4*d*, head of female 4*e* 4*f* male palpus

Figure 5 —*Tibellus duttonii* Keys, female, × 4, 5*a*, 5*b*, male palpus 5*c* epigynum

Figure 6 —*Thanatus lycosoides*, female × 4, 6*a*, 6*b*, male palpus, 6*c* epigynum

XXII.—The Marine Nemerteans of New England and Adjacent Waters. By A. E. Verrill.

The following article is intended as a descriptive catalogue of all the Nemerteans of the North-eastern Coast of North America that have been observed with enough care to permit me to give a description presumably sufficient to enable ordinary observers to identify the species when seen living. Therefore all my own descriptions, herein given, have been made from living specimens, except in a few special instances, which are, in each case, particularly stated.

As a rule, undetermined alcoholic specimens of Nemerteans, unaccompanied by notes on their forms and colors while living, cannot be identified with certainty unless they belong to genera containing very few and widely differing species. To distinguish the numerous species of *Amphiporus*, *Tetrastemma*, *Lineus*, etc., with alcoholic specimens alone, would be a hopeless task, at least in the present state of our knowledge of these groups. Possibly, when all the known species shall have been studied thoroughly by means of microscopic sections, it may be possible to distinguish many of the species by means of such sections of preserved specimens, but that will be a condition possible only in the distant future, and in any case would require much time and labor.

Exceptional cases are, however, not uncommon in which some prominent feature may be preserved in the alcoholic specimens sufficiently well to enable the species to be recognized with certainty. Thus, among the *Enopla*, the stylets of the proboscis are frequently characteristic in form or number. The ocelli, often visible in alcoholic specimens, may also be characteristic. In a few cases, even the characteristic colors may be preserved many years in alcohol, and still better in glycerine. I have specimens of *Amphiporus angulatus* (*Stimpsoni*), preserved in alcohol twenty years ago, in which the dark purple color of the body and the characteristic white patches on the sides of the head are still very distinct. These specimens have, however, been kept in dark drawers; those that were exposed to light faded many years ago.

In consequence of the difficulty or impossibility of identifying alcoholic specimens, I have, in this article, made very little use of a

large part of the vast collection of American Nemerteans preserved in the Museum of Yale University, and including those collected by myself and others during the explorations carried on from 1871 to 1887 by the United States Fish Commission, under the direction of the late Commissioner, Professor S. F. Baird.

These collections include several thousands of specimens, filling more than a thousand bottles and jars. They represent very fully the Nemertean and Planarian fauna of the coast, from Cape Hatteras to Labrador, and from high-water mark to 2000 fathoms. Fortunately I personally identified and labelled when captured a large number of those specimens that belonged to described species, and made copious descriptions and sketches of most of the unfamiliar forms that came, while still living, under my observation during all the sixteen seasons spent on the work of the U. S. Fish Commission, as well as during several summers (1864 to 1870) spent in independent researches in the waters of the Bay of Fundy and elsewhere. But there were many specimens, especially deep-water forms, that I did not see until they had been placed in alcohol. Most of those are entirely omitted from this paper. Probably they include a number of additional species.

Many of the general figures accompanying this article were made from life by Mr. J. H. Emerton and Mr. J. H. Blake, under my direction, for the U. S. Fish Commission. For the privilege of using these drawings for the present purpose, I am indebted to the late commissioner, Professor Baird, this article having been in preparation before his death. Other figures have been drawn by myself for this paper. Numerous figures, taken from my own field-notes and rough sketches, have been copied and put into shape by my son, A. H. Verrill, under my personal supervision. The latter are, therefore, quite as reliable as the former ones. A few anatomical figures (on Pl. XXXIX) have been copied from the works of McIntosh* and Hubrecht,† in order to illustrate more fully some of the differences between the orders and sub-orders of Nemerteans.

It was originally a part of my intention to have included numerous anatomical details of our native species, based on new preparations and studies, but various circumstances have compelled me to defer that portion of the subject to a future time. Such details are, however, less essential in the case of our Nemerteans than they

* A Monograph of the British Annelids. Part I. The Nemerteans. Ray Society, 1873.

† Voyage of the Challenger, vol. xix.

otherwise would have been, because many of our native species are closely allied to, and several others are identical with, some of those that have been well studied anatomically by McIntosh and other European writers.

Nemerteans are almost universally present on our shores, between tides at all levels, from near high-water (*Lineus socialis*) downward. They are also to be found, by dredging, at all depths down to 1000 fathoms or more, but are much more abundant in shallow water (1 to 60 fathoms) than at greater depths. They occur on all kinds of bottoms, but are usually more abundant in soft and partially organic mud than elsewhere. But in rather shallow water, on some hard bottoms overgrown with ascidians, hydroids, and sponges they are often very abundant, especially in the Bay of Fundy. The littoral Nemerteans occur in greater numbers and of more numerous species on the rocky shores of the Bay of Fundy, and especially in Eastport harbor, than in any other localities where I have collected them.

On sandy shores, also, there are nearly always several species living buried in the sand, to be found easily by the use of a spade These sand-dwelling forms include the largest species of *Cerebratulus*, which are, perhaps, the largest of all Nemerteans.

NEMERTINA.

The Nemertinea may be characterized as follows:

Smooth, ciliated, often bright colored, and mostly marine worms, destitute of external paired appendages, usually with a long and somewhat flattened body, often almost linear; without definite body-cavity. Muscular walls of body thick and complex, not segmented.

Head not very distinct from the body; mouth ventral, beneath the head, or subterminal, without teeth or jaws.

Intestine large, usually straight and furnished with many short, lateral, saccular, often lobed appendages; anus posterior.

A long, tubular, dorsal proboscis is contained in a special muscular sheath, which is filled with a corpusculated fluid and situated above the intestine but entirely separated from it. The proboscis can be protruded by eversion from a special aperture at the front of the head.

Two pairs of cephalic ganglions are present; they are united transversely by an upper and a lower commissure, between which pass the proboscis and its sheath. Most species have ciliated pits or sacs connected with the posterior ganglions by ducts leading from

fossæ or grooves on the sides of the head. They are probably olfactory organs. Two large lateral nerves run back from the lower cephalic ganglions; often there is also a smaller median dorsal nerve trunk, and in many there is a continuous nervous plexus between the muscular layers of the body-wall.

Vascular system closed ; a main longitudinal vessel runs along each side and usually a median dorsal one is situated above the intestine; the blood is usually colorless, rarely red.

A paired nephridial system, consisting of ducts and tubules variously arranged, is usually present in the œsophageal region.

The sexes are almost always separate and nearly all the species are oviparous. Reproductive organs are very simple and similar in both sexes, consisting of simple saccular ovaries or spermaries, situated along the sides of the body, usually between the lateral saccules of the intestine. External genital openings are mere pores in the body-wall.

Development is usually direct, but sometimes with a metamorphosis through a *Pilidium*, or free swimming larval form, very peculiar in structure. (Plate XXXIX, figures 1 to 6).

Order I, ENOPLA.

Enopla M Schultz; McIntosh, Brit Annelids, Part I, Nemerteans, pp 36, 43, 134
Hoplonemertini Hubrecht; Carus, Fauna Mediterranea, p 163, 1884.
Hoplonemertea Hubrecht; Voy. Challenger, vol xix, p 15.

Proboscis divided into three distinct regions (Plate XXXIX, figures 7, 8, 9); the first is evertible and tubular ; the middle region (woodcut 1), is furnished with a hollow muscular bulb and a complex armature, consisting of a central calcareous stylet (c), or a toothed plate, usually accompanied by two or more lateral chambers containing small, pin-like, free spines or stylets (figures 7, 7*a*, and woodcut 1, D, D′). The central cavity of the bulb and the lateral styliferous chambers communicate with the anterior evertible chamber of the proboscis by means of ducts. Proboscis-pore is either terminal, at the end of the snout, or subventral.

Fig. 1. Armature of proboscis of *Amphiporus lactifloreus*, A, muscular bulb; B, its cavity; C, central stylet; D, D′, lateral stylet-sacs. E, duct of D, H, muscular band, (after McIntosh).

The mouth is small and inconspicuous when contracted, situated beneath the end of the snout and in front of the cephalic ganglions, often in close connection with the proboscis-pore.

Lateral longitudinal cephalic slits are wanting and are generally replaced by shallow, transverse or oblique, ciliated grooves or fossæ, connected by narrow ducts with small sacs (probably olfactory in function) that connect them with the posterior ganglions.

Cephalic ganglions rounded, the upper or anterior ones closely united to and largely covering the lower ones. Lateral nerves arise from the posterior ends of the inferior ganglions and run back within the inner muscular layer of the body-wall.

Ocelli various, often numerous; sometimes wanting.

Three large, longitudinal vascular trunks are well developed; a vascular loop in the head.

Intestine large and straight, sacculated. Muscular walls of the body consist mainly of two layers, an outer circular, and an inner longitudinal one.

The young, so far as known, undergo no marked metamorphosis.

The species are chiefly marine; a few fresh-water and terrestrial species are known.

Family, AMPHIPORIDÆ McIntosh (restr.)

Body moderately elongated. Proboscis with a thick, tubular, evertible anterior portion, its walls consisting of about seven layers, the inner surface (or outer when protruded) thickly covered with papillæ; middle region furnished with a simple central stylet and generally two or four lateral chambers containing pin-shaped stylets, but the lateral sacs are sometimes wanting; posterior region tubular, with two muscular layers, an outer circular and an inner longitudinal layer. Œsophagus with a dilated and plicated anterior portion in the head.

The family *Tetrastemmidæ* Hubr. is here included. I can find no characters that seem to me sufficient to warrant even a sub-family distinction between *Tetrastemma* and *Amphiporus*.

On the other hand, I would separate *Drepanophorus* Hubr. as a separate family, DREPANOPHORIDÆ, characterized by having the central armature of the proboscis in the form of a lamina or plate, bearing several stylets or denticles; by the numerous styliferous sacs; and by the presence of lateral cæcal sacs connected with the sheath of the proboscis.

Amphiporus Ehrenberg, 1831, McIntosh, *non* Dies., *nec* Œrsted

Ommatoplea Ehr., Symbolæ Physicæ, 1831
Omatoplea Diesing, Syst Helm vol i, p 248 1850
Polystemma Ehr., 1831, Œrsted, Naturhist Tidssk. iv, p 579, 1844.
Polia Quatr (*pars*), Ann des Sci Nat, vi, p 201, 1846 *non* Delle Chiaje, 1841
Cosmocephala Stimpson Prodromus, in Proc Acad Nat Sci, Philad vol ix, p. 165 [21 sep copy] 1857
Polina Stimpson, op cit, p 165
Ophionemertes Verrill Amer Journ Sci, vol vii, p 45, 1873, Proc Amer Assoc, 1873, p 389, 1873

Body only moderately elongated, in some species slender, in others stout; usually strongly convex dorsally and with rounded sides.

Head often distinct from the narrowed neck, but in other cases of the same breadth as the body and without any definite limitation

Transverse or oblique ciliated fossæ or shallow grooves, two of them connected with the ciliated sensory ducts, are, apparently, always present, though often very indistinct; usually there is a pair at the back of the head and nearly in line with, or just behind, the posterior ocelli and the ganglions; the other pair, situated in front of the ganglions, is usually less distinct and may be easily overlooked, and is perhaps absent in some species One or both pairs of fossæ may meet on the dorsal line in certain species.

Ocelli usually numerous, variously arranged; perhaps the most common or typical arrangement is that of two anterior groups and two posterior or cerebral clusters, but either pair may be lacking, or the two groups may blend, and sometimes no ocelli are visible

Proboscis-pore terminal, or sometimes sub-terminal, just under the tip of the snout. Proboscis large and long Central armature a simple, sharp stylet with thick base; lateral stylet-sacs usually two, each with two to four, or more, pin-shaped stylets

Mouth far forward, usually united with the proboscis-pore, and therefore not visible in contraction.

The numerous species belonging to this genus* were distributed

* Many authors, of whom a few are indicated in the synonymy have used *Ommatoplea* Ehr as the name of this genus and on many accounts it seems to me that it would have been better to have continued that usage McIntosh, in his monograph, has, however, seen fit to change the name to *Amphiporus* (of the same date) for reasons that are to say the least, of questionable validity,—mainly because somebody *may* hereafter discover that the "type" of *Ommatoplea* is of a different genus though he gives no reason for supposing that to be the case In this instance long usage

among a large number of genera by the earlier writers, especially by those who did not observe the armature of the proboscis, or did not consider it of importance.

In general, it is impossible to distinguish the species of this genus from other genera without an examination of the proboscis and its armature. Hence, no doubt, there are many still unrecognized species of the genus that were formerly described under other genera, from various foreign countries. I believe, however, that all the species hitherto described or mentioned as found on our coast are included in the following list, together with several that appear to be undescribed.

Œrsted adopted *Polystemma* for this genus, and placed under it two typical species; *P. roseum* and *P. pulchrum*. At the same time he restricted *Amphiporus* to the genus named *Nemertes* (new sense) by McIntosh, giving its essential character (a small proboscis) and naming *A. Neesii* as the type.

Subgenera of Amphiporus.

The genus may be conveniently divided into several groups or subgenera based primarily on the arrangement of the ocelli and nerves, as follows:

I. Ocelli form four or more distinct groups; the two cerebral groups are distinct from the anterior ones.—*Ommatoplea*, subgenus.

1*a*. Anterior ocelli do not form curved rows parallel with the lateral margins of the head.

Amphiporus angulatus (Fabr.).
A. multisorus V., sp nov.
A. heterosorus V., sp. nov
A tetrasorus V., sp. nov

1*b*. Anterior groups of ocelli form curved rows parallel, at least in part, with the sides of the head.—*Polystemma* Œrs.; *Polina* Stimp.

A. roseus (Müller).
A. lactifloreus (Johnst).
A. ochraceus V.
A. glutinosus V.
A. griseus (Stimp.).

would have justified him in not making the change before there was any proof of the necessity for doing so

The change having been made in so important a work, has been generally adopted by later European authors, and I have, therefore, followed their example in this article, for uniformity of nomenclature in this group is at present of paramount importance.

II. Only two distinct groups of ocelli, anterior or sub-lateral; cerebral groups obscure or wanting.—*Cosmocephala* Stimp

2*a*. Only anterior groups of ocelli are evident
A frontalis V , sp nov

2*b* Only median lateral groups of ocelli are present, or else the median and cerebral groups are blended
A mesosorus V , sp nov

III Ocelli form only elongated lateral rows more or less parallel with the sides of the head, cerebral groups are not distinct from the others Body slender —*Ophionemertes* Verrill
A cruentatus V
A virescens V
A agilis V

IV Only a single pair of anterior ocelli are present --*Dichilus* Stimp
A bioculatus McInt

V Ocelli indistinct or absent —*Naredopsis* Verrill, sub-gen nov
A caecus V , sp nov

VI Ocelli doubtful, forming at least a pair of antero-lateral groups (perhaps others that are not observed)
A thallius V , sp nov

VII Cerebral groups of ocelli (?) alone observed (perhaps anterior ocelli overlooked).—*Nareda* Girard
A superbus (Gir)

Amphiporus

Analytical Table of species based on the arrangement of the ocelli

A Ocelli present

B Ocelli numerous, arranged in groups

C Ocelli arranged in four groups, two cerebral, near the ganglions and two anterior or antero-lateral

D Anterior clusters of ocelli transverse, at the front margin of the head posterior groups roundish

a Anterior groups transversely oblong or partly double *A angulatus*

aa Anterior groups each divided into three subordinate clusters *A multisorus*

DD Anterior clusters are not transverse at the front margin

b Anterior clusters subdorsal, not parallel with the margins of head

c Anterior clusters are triangular with the acute angle backward *A heterosorus.*

cc Anterior clusters are oblique rows parallel with the posterior ones *A tetrasorus.*

bb Anterior clusters lateral or sublateral, curved or crescent shaped, anteriorly partly parallel with the margins of head.

e. Posterior groups form round or angular close clusters

f. Anterior groups are large, composed of several rows posteriorly, and nearly blend with posterior groups. *A. roseus.*

ff. Anterior groups are more simple, distinctly separated from the posterior clusters, composed of one or two rows, and regularly curved. *A. lactifloreus.*

ee. Posterior groups of few ocelli, which do not form close clusters.

g. Posterior groups consist of one, two, or rarely three, oblique pairs of ocelli on each side.

h. Posterior pairs usually two on each side, convergent backward. *A. ochraceus.*

hh Posterior pairs of ocelli divergent backward. *A. glutinosus*

gg. Posterior groups linear, each of about four ocelli. *A. griseus*

CC. Ocelli arranged in only two distinct clusters.

a. Clusters transverse, short, in front of ganglions.

b. Clusters transverse, near front margin of head. *A. frontalis.*

bb. A large angular cluster on each side of the middle of the head. *A. mesosorus.*

aa Clusters of ocelli elongated, lateral, parallel with the margins of the head.

c. Ocelli forming a simple row on each side of head. *A cruentatus.*

cc Ocelli in double or triple rows.

d. Ocelli in two or three nearly parallel rows extending back of ganglions *A. virescens.*

dd Rows of ocelli broad, terminating at the ganglions. *A. agilis.*

BB. Ocelli two only, near the front of head. *A. bioculatus.*

AA Ocelli wanting or indistinct. *A. cæcus.*

Species not included in the above table:

Amphiporus thallius. Ocelli doubtful; only front groups observed.

Amphiporus (?) *superbus.* Ocelli doubtful; apparently two cerebral groups only.

Amphiporus angulatus (Fabr.) Verrill.

Fasciola angulata O Fabr., in O. F. Müller, Verm. Terrest et Fluv, i pp. 58 1774

Planaria angulata O Fabr, in Müller, Zool Danic, Prod, p 221, 1776. (Communicated by O Fabricius, t. Müller).

Planaria angulata O. Fabr., Fauna Grœnlandica, p. 323, 1780.

Omatoplea Stimpsonii Girard, in Stimpson, Invert of Grand Menan, p 28, pl. 2, fig 18, 1853.

Amphiporus Stimpsoni Verrill, Notice of Recent Addit to Mar Invert., Part I, in Proc. National Mus, vol ii, p 184, 1879; Check List Marine Invert. Atlantic Coast, p 12, 1879, Bulletin U. S Nat Museum, No 15, p. 143, 1879 (from Cumberland Gulf)

Amphiporus Fabricii Levinsen, Bidrag til Kundskab om Grœnlands Turbellariefauna, p 38, 1879, from Vidensk. Meddel. fra den naturh. Foren i Kbhvn., 1879–80, p. 200.

PLATE XXXIII, FIGURES 1, 1*a*, 2.

Body large and stout, only moderately elongated in extension; back convex, sides well rounded, lower surface flattened. The body is very changeable in form and can contract into a short, thick,

oblong mass; the posterior end is often the broadest part, but frequently in extension the breadth is nearly uniform throughout most of the length; posterior end obtuse. Head usually more or less distinctly defined, often broader than the neck, oblong or ovate in form, rounded or obtuse in front, nearly always with a conspicuous, pale, angular spot on each side. Ocelli numerous, arranged in two frontal clusters on the white marginal area, and in two dorsal groups; each of the anterior or frontal ones consists of numerous small ocelli arranged in two or more close rows forming an oblong or crescent shaped cluster close to the antero-lateral margin of the head; in some cases each of these clusters is double, consisting of a larger, outer or lower group and an upper, smaller one; but these subordinate clusters are usually more or less blended; the dorsal groups are smaller and of fewer ocelli, rounded, and situated at the postero-dorsal part of the head, close to the ganglions, and usually on, or just in front of, a narrow whitish line across the neck which marks the position of the transverse fossæ. Proboscis large, covered with small papillæ. Color of body, above, and middle of head usually deep purple, madder-brown, or purplish brown, sometimes plum-color, chocolate-brown, reddish brown, and orange-brown; sides and lower surface much paler brown, often flesh-color or pinkish. The head is whitish in front and is almost always conspicuously marked with two large angular spots or patches of whitish or flesh-color on the sides above; most frequently these spots are broad, triangular or trapezoidal, with the apices directed toward the median line above, but separated by a wide dorsal stripe of dark color like that of the body; in other cases the apices of these spots are more truncated, giving a broad, somewhat squarish form, the shape varying with the extension of the head; a little back of the spots a narrow angulated white line, corresponding to the transverse fossæ, crosses the neck, but it is sometimes absent; in front of the angular spots there is usually another, more conspicuous, white line or narrow band across the dark pigment of the head, but this is sometimes interrupted dorsally and is then represented by a narrow triangular spot of white on each side of the head; proboscis, when protruded, reddish.

Length up to 100 to 150^{mm}; diameter 6 to 8^{mm} or more.

Massachusetts Bay to Gulf of St. Lawrence, Labrador, Cumberland Gulf, and Greenland. Very common and of large size at low-water mark, under stones, at Eastport, Me., and Grand Menan, N. B. I have also dredged it in numerous localities off Nova Scotia; in the Bay of Fundy; off the coast of Maine; Casco Bay; off Cape

Ann; off Cape Cod, etc., in 4 to 150 fathoms; and in the Gulf of St. Lawrence, 15 fathoms.

This large and conspicuous species is generally easily recognized by its clear, dark purplish or chocolate-brown color above, with pale margins and a trapezoidal or triangular white spot on each side of the head, and usually with a narrow white line across the neck; and by the pinkish or flesh-colored lower surface. Ocelli in two or more rows in an elongated group on each antero-lateral margin of the head, and a pair of small sub-dorsal clusters on the transverse white nuchal band.

The *Planaria angulata* of Otho Fabricius was, without doubt, based on this species; but his description being very brief, writers have hesitated in regard to this identification. His description of the characteristic white angular spots on the head, the color, and the habits could, however, apply to no other known species. The rediscovery of this species on the coast of Greenland by Levinsen, and its abundance in Cumberland Gulf, renders it quite certain that Fabricius had this species before him. Hence I have considered it necessary to restore his name.

This species and some of the others herein described, e. g. *A. frontalis*, evidently belong to the group for which Dr. Stimpson instituted the genus *Cosmocephala*. Among the characters given, the clusters of ocelli are said to be arranged on the antero-lateral margins of the head. The cerebral clusters may, perhaps, have been overlooked in at least one species. Dr. Stimpson has described two North Pacific species that are evidently closely allied to *A. angulatus*, viz:

Amphiporus Beringianus (*Cosmocephala Beringiana* St.) This was dredged in Bering Straits, in 5 fathoms. It closely resembles a light-colored variety of *A. angulatus* and may be identical with it.

Amphiporus Japonicus (*Cosmocephala Japonica* St.) was from Simoda, Japan, low water, among rocks. It differs more from our species than does the preceding. It is brown above, with a pale median line, with irregular pale spots on the head, and triangular cervical spots of white; clusters of ocelli are antero-lateral.*

* Prodromus, in Proc. Phil Acad. Nat Sci., ix, p. 165, 1857. The extensive collections of invertebrates made by Dr Stimpson on the North Pacific Exploring Expedition were nearly all destroyed in the great Chicago fire by which the Museum of the Chicago Academy of Science was burned. His original notes and drawings were burned at the same time. His colored figures of the Turbellaria and Nemerteans, which I had the pleasure of examining not long before the fire, were numerous and excellent. Had he been able to publish his figures subsequent writers would have found it easy to identify his new genera and species, briefly described in the Prodromus

Amphiporus multisorus Verrill, sp nov

PLATE XXVIII, FIGURE 3

Body moderately long, versatile. Head rather wider than the body, rather short, rounded in front, separated from the body by a slightly curved transverse fossa on each side. Front ocelli form six small rounded, submarginal clusters; three clusters each containing 3 or 4 ocelli, are on each side of the front of the head, arranged parallel with the margin; the posterior ocelli form two roundish, subdorsal clusters, each containing 6 to 8 ocelli, situated near the posterior part of the head, just in front of the pink ganglions.

Color of body, salmon or flesh-color, paler beneath

Length, in extension, 25 to 35^{mm}; diameter, 3 to 5^{mm}. Described from life.

Eastport, Me., at low water mark, and in 12 fathoms, 1870.

This species, in the form of the body and arrangement of the ocelli, is closely allied to *A. angulatus*, of which I formerly supposed it a pale variety. The very pale colors, total absence of the white patches on the head, and peculiar grouping of the anterior ocelli are characters that seem to warrant its separation as a distinct species, at least until intermediate specimens be discovered

Amphiporus heterosorus Verrill, sp nov

Amphiporus roseus (*pars*) Verrill, Notice of Recent Addit to Mar Invert, Part I, in Proc. National Mus, vol ii, p 183, 1879 (*non* Müller)

PLATE XXXIV, FIGURES 7, 17

Body rather stout, rounded, obtuse at each end, versatile. Head obtuse, usually rather wider than the body. Ocelli numerous, arranged in a pair of roundish clusters on the posterior part of the head, and in a pair of triangular clusters at the front; these triangular clusters, having their bases at the anterior margin of the head, extend upward and backward to near the middle of the head and end in an acute apex formed by a few ocelli, larger and more distinct than the rest. The posterior groups are smaller, wide apart, and distinctly separated from the anterior ones. A pair of shallow transverse fossæ, on the posterior part of the head, runs upward in line with the posterior groups of ocelli. Anterior fossæ were not noticed. Proboscis clavate in extension, large and long, equal to more than half the length, and about one-half the diameter of the body, finely papillose toward the end, and light brownish red in color.

Color of body, above, cherry-red, clear reddish brown, or light chocolate-brown; the sides and ventral surface flesh-color; a dark, medial, longitudinal line on the head.

Length, in extension, 30^{mm} to 50^{mm}; diameter 3^{mm} to 5^{mm}; length of proboscis, in extension, 25^{mm}; diameter $1 \cdot 5^{mm}$ (No. 5).

The specimens described above, from life, were taken off Cape Ann, Stat. 136 (U. S. F. C.), in 26 fath., sand, 1878. Eastport, Me.; Bay of Fundy; Gulf of Maine; Casco Bay; Massachusetts Bay; off Cape Cod; common in 10 to 200 fathoms, on muddy and sandy bottoms.

Amphiporus tetrasorus Verrill, sp. nov.

PLATE XXXIV, FIGURE 6.

Body very changeable, in extension roundish, rather thick, tapering but little, obtuse at both ends. Head as wide as body, usually obtuse or subtruncated in front, separated from the body by conspicuous transverse fossæ which curve upward and forward on each side; on the under side of the head these fossæ run forward, on each side, to the mouth. Ocelli numerous, forming two oblique, oblong, nearly parallel clusters on each side, the posterior ones just in front of, and parallel with, the transverse fossæ.

Color of body, above, chocolate-brown, darker medially; head, in front of eyes, white; body, beneath, whitish.

Length, 25 to 30^{mm}; diameter, 2^{mm}. The specimen described above, from life, was dredged at Station 132 (U. S. Fish Com.), off Cape Ann, Mass., in 45 fathoms, mud, July, 1878.

Amphiporus lactifloreus (Johnston) McIntosh

Planaria lactiflorea Johnston, Zool. Journal, vol. iii, p. 489, 1828.

Nemertes lactiflorea Johnston, Mag. Zool. and Bot., vol. i, p. 535, pl. XVII, f. 2 and 3, 1837.

Borlasia alba W. Thompson, Ann. Nat. Hist., vol. xv, p. 320 (with woodcut), 1845.

Polia mandilla Quatrefages, Ann. des sc. nat., 3me sér., Zool., tom. vi, p. 203, tab. 8, figs. 1 and 1*a*, and tab. 9, fig. 2, 1846.

Nemertes mandilla Diesing, Syst. Helm., vol. i, p. 274, 1850.

Omatoplea mutabilis Diesing, op. cit., p. 262, 1850.

Omatoplea rosea Johnston, Catalogue Brit. Mus., p. 23, plate II*a*, f. 2, 2*, 2**, 3, and 3*, 1865.

Omatoplea alba Johnston, op. cit., p. 23, 1865.

Amphiporus lactifloreus McIntosh, British Annelids, Part I, Nemerteans, p. 156, plate 1, figs. 1 and 2, 1873; Jensen, Turbellaria ad Lit. Norvegiæ, p. 80, 1878.

Amphiporus lactifloreus Verrill, Notice of Recent Addit. to Mar. Invert., Part I, in Proc. National Mus., ii, p. 184, 1879.

PLATE XXXIX, FIGURES 7, 7*a*.

Body rather elongated, roundish above and on the margins, flattened beneath, of nearly uniform breadth from the head to near

the posterior end. Head often somewhat expanded, a little flattened, obtuse or subacute in front according to state of extension. Ocelli form, on each side of head, a nearly simple submarginal row on the antero-lateral part, and behind the ends of each of these rows there is a small cluster of about three or four ocelli on each side, near the ganglions.

Color dull white, grayish, or pale flesh-color, often with a darker stripe along the back due to the proboscis-sheath; along the margins, especially beneath, the lateral sacs of the alimentary canal are often visible. Length 50 to 75^{mm}; diameter 4 to 6^{mm}, in extension. Eastport, Me., and Grand Menan, N. B., at low-water mark, under stones.

This species, which is here referred, with some doubt, to the European form, is not uncommon on the shores of the Bay of Fundy.

Amphiporus roseus (Muller).

Fasciola rosea O. F. Muller, Verm. terrest. et fluv hist., i, 2, p. 58, 1774.

Planaria rosea Müller, Zool Danic. Prodr., p 221, No 2679, 1776; Zool Danic., vol ii, p. 31, tab 64, fig. 1 and 2, 1788.

Nemertes pulchra Johnston, Mag. Zool and Bot, vol i, p 536, pl. xvii, fig 6, 1837

Polystemma roseum Œrsted, Kroyer's Nat Tidss, vol. iv, p. 579, 1837.

Polystemma pulchrum Œrsted, op. cit., p. 580, 1837.

Omatoplea rosea (*pars*) Diesing, Syst. Helm, vol. i, p 251, 1850.

Omatoplea pulchra Diesing, op. cit., p. 252, 1850.

Ommatoplea pulchra Johnston, Catalogue Brit. Mus., p 24, pl. IIa, fig. 6 and 6*, 1865.

Amphiporus pulcher McInt., British Annelids, Part I, Nemerteans, p. 158, pl. I, fig 3: PL. XIV, fig. 11, 1873.

PLATE XXXIV, FIGURES 5, 5*a*, 5*b*.

Body rather stout, not much elongated, tapering somewhat to both ends. Head usually broader than the body, ovate in extension, obtuse in front, separated from the body by a slightly marked, curved, transverse groove or fossa on each side. Ocelli numerous, arranged somewhat in four groups, the anterior pair lateral or submarginal, the posterior subdorsal; the anterior clusters form long, crescent-shaped groups or nearly simple rows on each side, running somewhat parallel with the antero-lateral margins of the head, but curving inward posteriorly, so that their posterior ends nearly meet on the median dorsal surface; the two posterior groups, which are opposite the hinder portion of the crescents and nearer the postero-lateral margins of the head, have an irregular roundish or ovate

form and are often almost united to the front groups by a few ocelli scattered between them.

Color of body, above, clear orange-red, paler beneath.

Length of the specimen described above, from life, 18 to 20^{mm}; breadth 5^{mm}. Massachusetts Bay to Bay of Fundy, in various localities, low-water to 112 fathoms. The specimens above described were taken at station 38, 1877, in 112 fathoms, off Grand Menan.

Amphiporus ochraceus Verrill, Check List Invert, 1879

Cosmocephala ochracea Verrill, Invert of Vineyard Sound, etc., pp 31, 336, pl XIX, figs 95, 95*a*, 1873

PLATE XXXIII, FIGURES 5, 6. PLATE XXXIX, FIGURE 8.

Body elongated, moderately slender, somewhat flattened, but thick, with the margins rounded, obtuse at both ends, or subacute posteriorly; broadest and often swollen anteriorly; gradually and

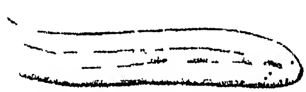

Fig. 2. *Amphiporus ochraceus.* Head and part of body, to show ocelli, enlarged

slightly tapering posteriorly; the integument is translucent and the internal organs show quite distinctly; lateral (saccular) organs voluminous, extending nearly the whole length of the body along each side, and showing through as dull yellowish white mottlings. Head usually ovate, slightly wider than the body, obtuse; a slight fossa or groove, usually appearing as a whitish line on each side, runs obliquely across the ventral and lateral surface of the head, diverging from the mouth and curving somewhat forward and upward at the sides; another, less distinct, is situated farther forward on each side of the head. Proboscis-pore small and inconspicuous in contraction; mouth, small. Ocelli numerous, but varying somewhat in number; the anterior ones form a submarginal curved row along each side of the head, anteriorly, but curve inward farther back; just back of these, on each side, there are usually four distinct posterior ocelli, standing two by two, obliquely. Color dull yellowish, or yellowish white, often tinged with deeper yellow or orange anteriorly, with the median line lighter; the position of the cephalic ganglions is shown by faint reddish spots between the posterior groups of ocelli.

Length, 50^{mm} to 70^{mm}; breadth, 2·5^{mm} to 3^{mm}.

The proboscis is large and thick (Pl. XXXIX, fig. 8). The central stylet (Pl. XXXIII, fig. 5*a*) has a rather narrow, oblong shaft, rounded at the base, and with broad basal alæ; the two lateral sacs usually contain only two stylets each.

Common between tides and in tide pools, under stones and creeping among algæ, hydroids, bryozoa, etc., on the piles of wharves and other similar places. Also dredged frequently in 2 to 20 fathoms, on stony or shelly bottoms, off New Haven, Conn.; Thimble Islands; Noank, Conn.; Newport, R. I.; Woods Holl, Mass.; also dredged at numerous other localities in Long Island Sound and Vineyard Sound. North of Cape Cod it is less abundant, but I have dredged it at many stations, at moderate depths, in Massachusetts Bay. It also occurred between tides on the north shore of Cape Cod, at Provincetown and Barnstable, Mass.

Amphiporus glutinosus Verrill.

Polina glutinosa Verrill, Invert. Animals of Vineyard Sound, etc., p. 337, plate XIX, fig. 97, 1873.

PLATE XXXV, FIGURE 5.

Body rather slender and elongated in extension, usually broadest in the middle and tapering to both ends, but quite versatile in form; head not distinct, usually obtuse; posterior end narrower, usually obtuse or slightly emarginate; integument soft, secreting a large quantity of mucus; the lateral organs extend close to the head. Ocelli numerous, variable in number, usually eight or ten on each

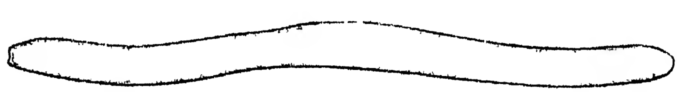

Fig. 3. *Amphiporus glutinosus.* Outline, enlarged.

side, arranged in three pairs of short, oblique, divergent rows, two to four in each; proboscis-pore moderately large terminal; no lateral fossæ were observed. Color dull yellow or pale orange-yellow, sometimes brighter orange, especially anteriorly; posteriorly usually lighter, with a faintly marked dusky or greenish median line.

Length, 25^{mm} to 30^{mm} in extension; breadth, $1{\cdot}3^{mm}$ to 2^{mm}. Great Egg Harbor, N. J., to New Haven, Conn., and Wood's Holl, Mass.; low-water mark to 6 fathoms, usually among hydroids and bryozoa.

Amphiporus griseus (Stimp.) Verrill

Polina grisea Stimp., Prodromus, in Proc. Philad. Acad. Nat. Sci., vol. ix, p. 164, 1857.

Body rather long, a little depressed, sub-cylindrical in extension, pale gray in color. Head distinct, ovate, or subcordate, narrower than the body, acute in front. Anterior clusters of ocelli larger, elongated, partly submarginal on the antero-lateral margin of the head; ocelli ten in each cluster. Posterior clusters cervical, small, linear, with four ocelli in each.

Length 0·8 inch; breadth 0·04 inch.

In the harbor of Norfolk, Va., sublittoral, among algæ in muddy places.

The above is a translation of Dr. Stimpson's Latin diagnosis. The species appears to be closely allied to *A. glutinosus.*

Amphiporus frontalis Verrill, sp. nov.

PLATE XXXIV, FIGURES 1, 1*a*, 1*b*, 8.

Body large, versatile in form, rather elongated, convex above, but somewhat depressed in extension, of nearly uniform breadth to near the ends, which are obtuse. Head in extension usually broader than the neck and separated by a slight constriction, usually longer than broad, but it may shorten into short ovate or broad rounded forms; front margin often emarginate. A well-marked, but shallow, oblique, transverse, ciliated fossa at the posterior border of the head, on each side, curves inward and usually somewhat forward, but does not reach the middle line; in some states of contraction these fossæ curve backward; underneath, the fossæ run very obliquely backward and inward, when the head is extended. Near the front of the head, on each side, a short curved fossa runs inward and curves forward, nearly parallel with the posterior ones, beneath the head they curve inward and backward but they recede in a V-shaped curve on each side of the head. Ocelli rather large and conspicuous, blackish, arranged in a single irregular cluster, or double row, of six to eight or more, on each side of the front and near the margin of the head. Mouth close to the proboscis-pore.

Color translucent white, or pale gray, or yellowish, with a darker dorsal band; sides of body mottled with pale pink or yellowish, due to the internal organs.

A variety taken at Eastport, Me., at low water, 1868, was translucent pale salmon, or flesh-color, mottled laterally with purplish and yellowish, due to the internal organs, while the median dorsal

region was greenish, apparently due to the contents of the intestine. Ocelli about 10 in each cluster.

Length, in extension, 100^{mm}; diameter 3^{mm}.

Length 25 to 125^{mm}; breadth about 3 to 5^{mm}. An individual 5 inches long can contract to less than 2 inches.

Eastport, Maine, low water, 1868 and 1870.

Amphiporus mesosorus Verrill, sp. nov.

PLATE XXXIV, FIGURE 9.

Body not much elongated, rather thick, well-rounded. Head of the same breadth as the neck, obtuse in front. Posterior transverse fossæ rather shallow and indistinct. Ocelli numerous, forming a large, irregular, somewhat triangular cluster on each side of the middle of the head, the apex of the groups pointing backward toward the ganglions. In some cases these clusters seem to consist of two rather roundish cerebral groups, which blend with two short, triangular lateral groups.

Color above, bright red; beneath, flesh-color. Length 50^{mm}; breadth 3^{mm}.

Massachusetts Bay, off Salem, Aug. 13, 1877, station 30 (three specimens)

Amphiporus cruentatus Verrill, Proc. U. S. Nat. Mus., vol ii, p. 184, 1879

PLATE XXVIII, FIGURES 7, 8, 8*a*, PLATE XXXV, FIGURE 3, PLATE XXXIX, FIGURE 9

A species peculiarly characterized by having red blood, so that the longitudinal vessels appear distinctly red through the translucent integument. Body soft, flaccid, versatile, in full extension slender, tapering to both ends, but capable of becoming thicker and obtuse or even swollen posteriorly, and of contracting into a short stout form. Head not very distinct, scarcely broader than the neck, snout strongly ciliated. Ocelli about 8 to 12 on each side of the head, in a simple, interrupted, longitudinal, sublateral row, the most anterior ocellus distinctly the largest. Two slight transverse grooves on each side of the head, apparently not extending across the dorsal side, the anterior ones curving forward in front of, and the posterior ones behind the ganglia. Proboscis long, densely covered with elongated, conical papillæ; a simple central stylet, with two small, pin-shaped lateral ones on each side (Pl. XXXIX, fig. 9).

Color light flesh-color or yellowish white with conspicuous bright red median and lateral blood-vessels.

Length 25^{mm} to 40^{mm}.

Vineyard Sound, 4 to 10 fathoms; off Newport, R. I., 3 to 8 fathoms. Not very common.

Amphiporus virescens Verrill Proc Nat Mus, p 183 1879

Nemertes, sp undet (?) Verrill, Invert Vineyard Sd p 335, 1873

PLATE XXXIII FIGURES 4, 4*a* 4*b*, 4*c* 4*d*, 4*e*

Body, in extension, broadest anteriorly, rather depressed, long, slender, tapering gradually to the rather attenuated posterior end. Active in its movements. Head changeable in form, rather large, in expansion usually ovate, broader than the body, depressed, and obtusely rounded in front. A pair of faintly marked, nearly trans verse fossæ runs up on each side of the posterior part of the head, crossing the rows of ocelli; farther forward and parallel with these there is another pair of similar furrows that cross the eye patches and beneath the head curve forward to the mouth Ocelli numer ous, forming a long lateral cluster on each side of the head; ante riorly each cluster consists of three or more rows, but backward the interior rows cease, finally leaving only the outer row, which ex tends back beyond the head and neck. Proboscis in partial exten sion clavate and covered with prominent papillæ; central style with an oblong shank, which in one mounted specimen is ligh greenish blue, together with the transverse, pigmented band near it

Color clear light green, varying in tint.

Length of largest specimen seen, about 40^{mm}. New Haven and Noank, Conn.; Newport, R. I.; Wood's Holl, Mass., etc. Common in shallow water among hydroids and ascidians, and on the pile of wharves between tides.

Amphiporus agilis Verrill.

Ophionemertes agilis Verrill Am Jour Science, vii, p 45, pl 7, fig 1, 1873, Verrill, Expl of Casco Bay, in Proc. Amer Assoc for 1873, p 389, pl 2, fig 4

Amphiporus agilis Verrill, Notice of Recent Addit to Mar Invert, Part I, in Proc National Mus, ii, p 183, 1879

PLATE XXXV, FIGURE 4.

Body versatile, slender and elongated in extension, slightly de pressed, with the sides well rounded, thickest in the middle, taper ing gradually to the slender, obtuse posterior end. Head some what separate from, and wider than, the anterior part of the body changeable in form, often oval, sometimes sub-triangular, generall

longer than broad, narrowed anteriorly, obtuse or slightly emarginate, with a terminal proboscis-pore. Ocelli numerous, forming

Fig 4 *Amphiporus agilis* Outline, enlarged

a long, crowded, lateral row or group along each side of the head, the rows are simple and convergent anteriorly, posteriorly they become broader and double. Back of the ocelli there is a curved transverse groove or fossa, crossing the back of the head. No anterior fossæ were observed. Color pale ocher-yellow; median dorsal line slightly reddish; the internal lateral organs lighter yellow, giving a reticulated appearance to the sides.

Length 25^{mm} to 40^{mm}; diameter 1.5^{mm} to 2^{mm}. Described from life (No. 546).

Casco Bay, 20 to 65 fathoms; Bay of Fundy, 10 to 90 fathoms; Massachusetts Bay and off Cape Cod, 12 to 60 fathoms.

This species is very active and restless. It creeps with a rapid gliding motion, frequently moving its head from side to side, and in confinement is apt to creep above the edge of the water and perish by drying up. It secretes mucus abundantly and forms tubes of that material. It also creeps on the surface of the water, back downward, like most of the species of *Tetrastemma*, which it closely resembles in habits.

Amphiporus bioculatus ? McIntosh.

PLATE XXXIV, FIGURES 3, 4, 15

Body rarely more than 1.5 inches long, soft, changeable in form, in extension usually rather short and thick, roundish, tapering only slightly toward the ends, which are usually obtuse; the posterior region is sometimes broader; head not wider than the body, not distinctly defined, in extension tapering to the front end, which is usually subacute; ocelli two, forming a pair, close together and near the front margin of the head. A pair of small, rather faint, anterior transverse fossæ passes upward and forward on the sides of the head, just back of the eyes, usually showing only as pale lines, apparently not meeting dorsally.

Color dark orange-red, varying to pale orange and salmon, with paler margins and ventral surfaces and usually with darker brownish mottlings along the sides posteriorly, due to the internal organs;

the large proboscis-sheath and proboscis can often be seen indistinctly along the median dorsal region.

Length, in extension, about 35 to 40^{mm}; diameter 2·5 to $3·5^{mm}$.

Length of a specimen from station 811, in 19 fathoms, 18 to 20^{mm}; diameter 1·25 to 2^{mm}.

Proboscis large; its armature consists of a slender central stylet having an elongated, narrow, oblong or cylindrical shaft, surrounded by a small dark-colored basal expansion. Below the stylet there is a dark pigmented transverse band. Described from living specimens.

Long Island Sound, near New Haven, etc.; Fisher's Island Sound; and Vineyard Sound, in 1 to 10 fathoms, not uncommon. Noank, Conn., in harbor mud, 1874. Off Block I., 19 fath., sand, (Sta 811).

Amphiporus cæcus Verrill, sp nov

Nemertes?, sp undet (*a*), Invert of Vineyard Sound, etc, p. 335, 1873.

PLATE XXXIV, FIGURES 2, 2*a*, 2*b*, 2*c*

Body soft, oblong, flattened, obtuse at both ends, the edges rounded. Head not distinctly separated from the body and of the same breadth; a faint whitish groove crosses the neck, receding in the middle above, and extends around on each side to the ventral surface, on which it advances in the middle, or runs directly across, according to the state of contraction. No ocelli. The cephalic ganglions can usually be seen through the integument of the head, especially on the lower side, as reddish spots.

Color bright orange-red; lighter orange-yellow along the sides; usually with a median dorsal stripe of darker red.

Length, in extension, 35 to 40^{mm}; diameter 2·5 to 3^{mm}. Described from living specimens.

North of Block Island, 18 to 20 fathoms, Aug. 6, 1874.

Amphiporus cæcus Young.

Body very slender. Head acute. Ocelli none. Proboscis with a central stylet having a narrow oblong shaft and expanded base, much as in that of *A. ochraceus;* lateral stylets not observed, perhaps wanting.

Color pale yellowish white, with the head red.

Length about 6 to 7^{mm}.

Station 812, in 28 fathoms, sand. Off Block Island, 1880.

Amphiporus thallius Verrill.

Amphiporus sp., Verrill, Bulletin U. S. Nat Mus, No. 15, p. 143, 1879 (with description).

Body, as preserved in alcohol, thick, not very long, somewhat depressed, tapered a little to both ends, which are obtuse. Head not very distinct, of the same width as the body; transverse fossæ at back part of head not very distinct, running back obliquely on each side, so as to form a V-shaped line on the middle above. Ocelli minute, arranged in a small roundish cluster on each side, on the pale antero-lateral margins.

Color, in alcohol, dark bluish green above; under surface and margins of head yellowish white. In life "bright pea-green" (Kumlin). Length, in alcohol, 25 to 30^{mm}; diameter 4 to 5^{mm}.

Cumberland Gulf, N. lat. 66°, October 4, 1887; Arctic Island, at low water, Sept. 13, 1877 (Kumlin coll.).

The very peculiar and strongly marked color, which persists for years in alcoholic specimens, appears to be characteristic of this species.

Amphiporus (?) superbus Verrill

Nareda superba Girard, in Stimpson, Invert. Grand Menan, p. 28, pl 2, fig 17, 1853.

PLATE XXXIV, FIGURE 16.

This species was dredged off Grand Menan in 40 fathoms by Dr. Wm. Stimpson. The description by Girard was evidently based on the drawing furnished him by Dr. Stimpson, and could not have furnished anything more than the external appearance. I have reproduced the original figure, somewhat reduced by photography. The original description is as follows:

"NAREDA Grd."

"Body elongated, subcylindrical. Head obtusely triangular in front, neck slightly contracted; one pair of rounded ocelli."

"*N. superba* Grd.—Length from one to two inches; body posteriorly attenuated; head forming an equilateral triangle; the base of which is at the contracted neck. Color above uniform soft red; head margined by a narrow band of white. The neck is also marked by a transverse band of white, on which the eyes are situated, far apart. Below white. Dredged in thirty-five fathoms, in the Hake Bay."

The only character mentioned which could have been considered as of generic value is the presence of two eyes (?) on the white

nuchal band. But it is much more probable that those spots repı sented either the cephalic ganglions, which usually show themselv in that position in this group, or else clusters of small ocelli.

In the latter case there may also have been small anterior oce that were overlooked. Either supposition is consistent with its su posed relation to the known species of *Amphiporus* with many which it agrees in form.

Although I have spent part of several summers dredging in t region of Grand Menan, and have dredged even in the same localı where this species was obtained, I have never met with a Nem tean that could be referred to the same species with certainty, ev after making allowances for errors in the original drawing T nearest approach to it that I have seen, is a red variety of *A. ang latus* in which the angular pale spots on the sides of the head a nearly obsolete, and the front ocelli inconspicuous. I have, the fore, reproduced the original description and figure.

Tetrastemma Ehrenberg, 1831

Polia (*pars*) Quatr, Ann des sci nat, vol vi, 1846

Œrstedia Quatr, op cit, p 221; Dies, Syst Helm, vol i, p 247 (*non* Hubrecht

Tetrastemma Diesing, Syst Helm, vol i, p. 256, 1850, Stimpson, Prodromus, Acad. Nat. Sci Philad, p. 163 [19], 1853

Nemertes (*pars*) Dies., Syst Helm., vol i, p 269, 1850

Body rather small, moderately elongated, often nearly tere Head in some species wider than neck, but in many species of t same breadth. Transverse fossæ usually two on each side of t head, more or less oblique. Ocelli four, arranged in a quadrang Proboscis with a central stylet and two lateral chambers, ea usually containing two to four stylets.

A terrestrial species of *Tetrastemma* (*T. agricola*) has b described from the Bermudas by Moseley. Fresh water species the same, or a closely allied genus, are also known.

Tetrastemma candidum (Fabr.) Œrsted

? *Fasciola candida* O Fabr in O. F. Müller, Verm terrest. et fluv. hist, I, ii, p 1774.

? *Planaria candida* O Fabr. in O F. Müller, Zool. Dan Prodr., p 223, No 27 1776; O Fabricius, Fauna Grœnlandica, p. 327, 1780.

Planaria quadrioculata (*pars*) Johnston, Zool. Jour., vol. iv, p. 56, 1829

Nemertes quadrioculata Johnston, Mag. Zool. and Bot., vol. i, p 535, pl. xvii, fig 1837.

Tetrastemma varicolor (*pars*) Œrsted, Kroyer's Naturhist. Tidss, iv, p 575, 18 Diesing. Syst. Helm., vol. i. p. 257. 1850.

Tetrastemma grœnlandicum Diesing, op. cit., p. 259

Tetrastemma candida McIntosh, British Annelids, Part I, Nemerteans, p 167, pl II, figs 2, 3, 1873 (*non* Diesing, Syst.); Levinsen, Grønlands Turbell., p 39 [200], 1879; Verrill, Amer Jour Sci, vol x, p. 40, 1875; Check List, 1879

PLATE XXXIII, FIGURES 9, 10, 10*a*; PLATE XXXV, FIGURES 9, 10.

Body very contractile, in extension slender, elongated, somewhat depressed, tapering backward and often attenuated toward the posterior end. Head in usual extension rather wider than the body. Ocelli rather large, conspicuous, reddish brown, nearly in a square, but when the head is fully extended, the two pairs are farther apart than the distance between those of a pair.

Color variable, usually pale green, greenish white, or yellowish white, translucent, and generally with indistinct lateral grayish mottling, due to the internal organs; sometimes the intestinal area is decidedly greenish, while the sides are pale yellow; at other times the median region is whitish and the sides pale green. Several specimens, taken at Eastport, Me., in South Bay, 8 to 10 fathoms, mud, 1868, were clear cream color above, whitish below.

Length in extension 25 to 32^{mm}; diameter 1 to 2^{mm}.

Common at many localities between tides, among algæ, hydroids, and bryozoa from New Haven, Conn., to the Bay of Fundy. Also dredged at moderate depths, 1 to 14 fathoms, in many localities.

This species is very active; it creeps rapidly with a gliding motion. The relatively larger size of the head, more conspicuous eyes, and lighter colors, as contrasted with the following species, are its most distinctive characters.

It seems to me very doubtful whether the *Planaria candida* of Fabricius was this species. The large size and the habits given by him, and lack of mention of the eyes are against that view His species may have been *Amphiporus lactifloreus*, a Greenland species.

Tetrastemma candida. Variations.

Several specimens of the variety figured on plate XXXIII, figs. 10, 10*a*, were taken on the piles of the wharves at Gloucester, Mass., July 24, 1878. These were probably not full grown. The body was 8 to 12^{mm} long, in extension, slender, very changeable, usually of nearly uniform breadth to near the ends. Head obtuse and usually a little wider than the body, but very changeable in shape; when extended the ocelli were farther apart longitudinally than transversely, but when the head contracted, as in progression, the two pairs of ocelli were brought near together, as shown in the

figures. The form and direction of the two pairs of rather indistinct, transverse cephalic fossæ also varied greatly with the changes in the shape of the head. The two lateral stylet-sacs of the proboscis contained three stylets each.

Color of body, above, pale yellowish green, or pale brown; head with an opaque, flake-white spot in front of the eyes; along the margins of the body the internal organs produce series of brownish, irregular, transverse spots or blotches, varying in depth of color; alternating with these spots, and so interrupting the marginal dark bands, there are small, rounded whitish spots, probably due to the ovaries.

Tetrastemma elegans Verrill.

Tetrastemma elegans Verrill, Amer. Journ. Sci., vol. x, p. 40, 1875.

? *Hecate elegans* Girard, Proc. Boston Soc. Nat. Hist., vol, iv, p. 186, 1852.

PLATE XXXIV, FIGURE 10.

Body, in extension, longer and more slender than most species of the genus, depressed, broadest in the middle, tapering both ways. Head ovate, broader than the neck, obtuse or emarginate in front; lateral fossæ not very distinct. Ocelli conspicuous, nearly in a

Fig. 5. *Tetrastemma elegans.* Dorsal view.

square, the front pair rather nearer together than the others. Color above, striped with two broad brown lateral, and a wide median, yellow stripe; the median stripe is clearly defined, clear light yellow and occupies about a fourth of the breadth of the back; it extends to the front of the head, becoming narrow on the neck and then expanding on the middle of the head; a narrow ring of light yellow surrounds the neck, just behind the head; the two stripes of dark brown are well defined, but have irregular margins and are varied in color by paler specks; lower surface and margins of body and head pale yellow.

Length 20^{mm}; breadth 1 to 1·5^{mm}. Described from life.

Noank, Conn., among eel-grass; Fisher's Island Sound, 2 to 8 fathoms; Wood's Holl, Mass., on piles of wharf.

A paler variety occurs in which the lateral bands are lighter brown, interrupted by yellowish spots, and the dorsal stripe is less clearly defined.

Tetrastemma vermiculus (Quatr) Stimpson.

Polia vermiculus Quatrefages, Ann des sc. nat., ser. III, Zool, vol. vi, p 214, 1846, Voyage en Sicilie, vol. ii, p. 126, pl. xiv, figs 12, 13, 1849

Nemertes vermiculus Diesing, Syst. Helm., vol i, p. 270, 1850

Tetrastemma vermiculus Stimpson, Proc. Acad. Nat Sci Philad, vol ix, p 163 (19), 1857; Diesing, Revis der Turbell., p 290, 1862

Tetrastemma vermicula McIntosh, British Annelids Part I, Nemerteans, p 169, Plate iii, fig 3, 1873.

Tetrastemma vermiculus Verrill, Notice of Recent Addit. to Mar. Invert, Part I, in Proc. National Mus, ii, p 184, 1879, Check List, 1879.

PLATE XXXIII, FIGURES 11 to 11c, PLATE XXXIV, FIGURES 11, 12, PLATE XXXV, FIGURES 8, 11

Body versatile, rather slender in extension, obtuse at both ends; sometimes tapered to the posterior end, but more often of nearly uniform diameter. Ocelli conspicuous, the two pairs rather far apart when the head is extended, those on the same side farther separated than those of a single pair, and connected by a dark line of pigment, which is rarely absent.

Color rather variable; above, often pale yellowish, or pale salmon, or translucent yellowish gray, more or less specked or spotted, especially along the sides, with brown, often leaving a paler, wide, rather indefinite dorsal stripe; ventral surface and front of head pale.

Length, in extension, about 20^{mm}; breadth 1^{mm}. Described from life.

Many specimens taken at Wood's Holl in the mud of Little Harbor, July 25th, 1881, and August 4th, 1882, varied from dull orange-yellow to bright greenish yellow, more or less covered with specks of brown, especially on the sides, yet not forming a definite dorsal stripe, but with a darker brownish, often indistinct stripe on each side of the head between the eyes.

Length up to 18 to 20^{mm}.

Young—several young specimens of this species were taken together in a tide-pool, in 1878 (No. 12).

Body slender, of nearly the same width throughout. Ocelli conspicuous, the two pairs more widely separated than usual when the head is extended; the front ones a little larger than the others. Color translucent pale yellow, bright salmon, and flesh-color, usually with a white median spot in front of the anterior ocelli, and sometimes, also, with other white specks along the back; frequently an irregular brownish band runs along each side of the back; median line paler. In many of the specimens a faint longitudinal line of

dark brown pigment specks runs between the ocelli on each si In one example the median region, posteriorly, was green proba from the contents of the intestine showing through the integume

Gloucester, Mass., at Ten Pound Island, in a tide-pool at lc water, among algæ.

This European species is common among hydroids, bryozoa, asc ians, etc., between tides, on rocks, piles of wharves, and in tic pools, from Long Island Sound to the Bay of Fundy. I have, als often dredged it in 2 to 12 fathoms, at various localities on ha bottoms. It is especially abundant among ascidians in Vineya Sound, in 6 to 10 fathoms. Very common at Noank, Conn., in tl harbor, on muddy bottoms among eel-grass. Common in simil places and on piles of wharves, at Wood's Holl, Mass., and Newpor R. I.

Tetrastemma vermiculus, variety catenulatum nov

PLATE XXXIV, FIGURE 12, PLATE XXXV, FIGURE 11

Form and size essentially as above described Ground-color above, light salmon, pale yellow, or yellowish gray, thickly coverec along the sides with irregular specks, spots, or blotches of brown which at more or less irregular intervals extend upward toward or across the middle line, interrupting the median dorsal light stripe, which is often thus divided into a series of irregular oblong or elliptical spots; sometimes there is also a row of small brown spots along the median line; middle of head pale, often with flake-white specks; stripe of dark color, more or less distinct, between the two eyes of each side; lower surface pale yellow or yellowish white. Length up to 18^{mm}; diameter 1^{mm}. Described from life. Specimens of this marked variety are common in the harbor at Wood's Holl, Mass.

Other specimens, from the same locality, were noted as follows:

Body very changeable, often, in extension, narrow or sub-acute at both ends and more or less swollen in the middle, at one or more places, at other times nearly cylindrical or terete. Color pale yellowish or grayish green, with a darker central line on the pale dorsal stripe and with irregular, transverse, lateral markings. Or specks of darker brown are scattered over the back, and are often arranged in imperfect lateral stripes, leaving a paler, wide, more or less irregular and interrupted median stripe; lower surface pale. Ocelli reddish brown, forming nearly a square. Usually a line of dark pigment connects the two ocelli of the same side (No. 857).

Tetrastemma dorsale (Abildgaard) McInt.

Planaria dorsalis Abildgaard, Zool. Danic., vol. iv, p 25, tab. 142, figs. 1–3, 1806.
Tetrastemma fuscum Œrsted, Kroyer's Naturhist. Tidss., iv, p. 575, 1844.
Œrstedia maculata Quatr., Ann. Sci. Nat., ser. III, vol. vi, p. 222, pl. VIII, fig. 2.
Tetrastemma marmoratum Claparède, Beobach. über Anat u. Entwicklung., etc., p 24, pl. V, fig. 14, 1863 (variety).
Tetrastemma variegatum Johnston, Catalogue Brit Mus, pp. 20 and 289, 1865
Tetrastemma dorsalis McIntosh, British Annelids, Part I, Nemerteans, p 172. pl I, fig. 4; pl. III, fig 4, 1873; Verrill, Check List, 1879.
Tetrastemma dorsale Jensen, Turb. ad Litoria Norvegiæ, p 81, pl VIII, figs 9 to 12, 1878.

PLATE XXXIV, FIGURES 13, 14.

Body only moderately elongated, sub-terete, usually nearly cylindrical in extension, with both ends obtuse. Head not wider than the body, with two rather indistinct transverse fossæ on each side. Ocelli forming nearly a square; in full extension more distant longitudinally than transversely. Proboscis-pore a little below the end of the snout. Proboscis large, when protruded more than three-fourths the length of the body, thickly covered with acute papillæ.

Color variable; generally brown or dull reddish, with a well defined light dorsal stripe; or else variegated or mottled with two or more shades of brown, with or without the dorsal stripe.

Length up to 20^{mm}; diameter $1·5$ to 2^{mm}.

Variations.—Among the variations noted in life, are the following:—

Several examples were taken together at stations 310 to 313, off Cape Cod, in 15 to 21 fathoms, 1879.

In these the general color above was brownish, with a conspicuous pale, flesh-colored dorsal stripe, bordered with dark brown on each side; the brown lateral stripes were freckled with white specks; a pale line crosses the neck behind the eyes; front of the head, margins of the body and tip of the tail pale flesh-color. Pl. XXXIV, fig. 13.

Length 12 to 18^{mm}; diameter $1·5$ to 2^{mm}.

Other specimens had the following characters:

Body slender, 10^{mm} long; 1^{mm} broad. Color cinnamon-brown, specked with darker brown, and with a pale median line. Ocelli conspicuous, black. When the head is extended the two pairs are more distant than the space between those of the same pair. Proboscis large, more than three-fourths as long as the body, thickly covered with acute, conical papillæ, and protruded from a large pore, which is sub-ventral. Two slight transverse fossæ are seen on each side of the head.

Broad Sound, Casco Bay, July 22, 1873 (No. 721).

Tetrastemma dorsale, variety **marmoratum** (Clap)

PLATE XXXIV, FIGURE 14

Body terete, somewhat elongated in extension, obtuse at bot ends. Proboscis large, protruded from the sub-terminal pore thickly covered with papillæ. Color pale olive-brown, or chestnut brown, irregularly mottled and blotched with darker brown.

Length 18^{mm}; diameter $1{\cdot}5^{mm}$. Described from life (No. 735).

Portland, Me., in 2 to 3 fathoms, harbor mud, July 28, 1873.

A paler colored race, probably closely related to this variety, was taken in the harbor of Eastport, Me., in 12 fathoms, in 1872 (No 507). The body was changeable in form, usually nearly cylindrical, and obtuse at both ends. Ground-color pale yellow or salmon, thickly blotched and mottled with dark brown, or greenish brown; some specimens had an inconspicuous ring of yellowish white around the neck. Length 15 to 18^{mm}; diameter $1{\cdot}25$ to 2^{mm}.

Tetrastemma dorsale, variety **unicolor** Verrill, nov.

A specimen taken in Eastport Harbor, off Friar's Head, in 18 fathoms, August 20, 1870, agreed, with this species in form but differed so much in color that it probably ought to be considered as representing a distinct variety, at least:—

Body moderately slender, slightly depressed, with the sides rounded. Head obtuse, four distinct black ocelli. Color, above, uniform dark fuscous brown; lower surface paler.

Another specimen taken in 1879, according to the notes made from life, probably belongs to the same variety:—

Body moderate in extension, broadest at or behind the middle, tapering to both ends, not very slender. Ocelli well developed, the two pairs, when the head is extended, wider apart than the distance between those of the same pair. A very distinct transverse fossa, on each side of the head, runs upward and backward just in front of the posterior ocelli, but the two do not meet on the middle line. Color of the body, above, clear brown, the margins, head, and under surface paler.

Length 8^{mm}; breadth 1^{mm}.

Station 331, off Cape Cod, in 28 fathoms, 1879.

Tetrastemma vittatum Verrill.

American Journal of Science, vol vii, p 45, pl vii, figs 3, *a*, *b*, 1874, Proc Amer Assoc for Adv of Science for 1873, p 389, pl ii, figs 7, 8 1874, Verrill, Notice of Recent Addit to Mar Invert, Part I, in Proc National Mus, ii, p 185, 1879 (not *Œrstedia vittata* Hubr)

PLATE XXXV, FIGURES 6, 7

Body rather short and stout, up to 2 or 3 inches in length, soft, changeable, in extension nearly cylindrical but often a little flattened beneath, tapering slightly anteriorly, or sometimes both ways, usually obtuse at the posterior end.

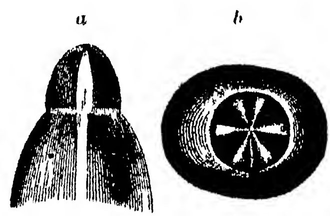

Fig 6 *Tetrastemma vittatum* *a*, head, dorsal view, *b*, front view, much enlarged

Head usually slightly narrower than the body, with a transverse groove or constriction in front of the posterior eyes; front end obtuse, conical, or rounded. Ocelli four, small, rather indistinct in dark colored specimens; the anterior ones are nearer together than the posterior, which are far back behind the transverse groove, which extends across, beneath, and crosses the median line above. Proboscis-pore terminal.

Color of body, above, dark or light olive green, dull yellowish green, or greenish brown, or even greenish black, often with two yellowish or light green dorsal stripes and sometimes with one median light stripe; beneath paler, mottled laterally. Color of head, in advance of the transverse groove, various shades of olive green and dark green, white at the tip, and with six longitudinal whitish or pale greenish stripes, which converge to the end; two of these stripes are dorsal, two are ventral, and one is lateral on each side; the green line between the two dorsal stripes extends back on the body. Internal organs show through the integument as irregular, short, transverse blotches or bars of lighter color along the sides beneath.

Length in extension usually about 25 to 30mm; diameter 3 to 4mm; unusually large examples have been taken as much as 75mm long, 6mm broad. Described from life.

Long Island Sound, Vineyard Sound, Massachusetts Bay, Casco Bay, Bay of Fundy, etc., low-water mark to 25 fathoms, common on muddy bottoms. Noank, Conn., in harbor mud, among eel-grass; Wood's Holl, Mass., harbor mud.

This species is sluggish in its habits and creeps very slowly

Tetrastemma vittatum. Variations

Several specimens of this species were taken together at station 310, off Cape Cod, in 21 fathoms, 1879.

These show great variation in the color of the body, which, in some was flesh-color, in others light olive-green, dark olive, light greenish brown, dark olive-brown, and dark smoky brown. All these varieties agree, however, in having the head greenish with the six light vittæ distinctly marked. In all the specimens the four ocelli were detected, but they are so indistinct in the dark specimens that they must be sought with care.

The largest specimens were 50 to 75^{mm} long; diameter up to 6^{mm}

Tetrastemma roseum Verrill, sp nov

Body round and soft, in extension about 1·25 inches long. Head obtusely conical; a transverse shallow groove close to the end of the snout; the part beyond the groove is capable of withdrawing under the portion behind it. Ocelli obscure; two behind the groove and (apparently) two very minute ones in front of it Color clear bright rosy red.

Length about 30^{mm}; diameter 3^{mm}.

Station 826, off Block Island, in 22 fathoms, 1880.

This species was met with only once, and then circumstances prevented a careful study of its structure. In the form of the body and characters of the head and cephalic grooves it resembles *T. vittatum* V., and if the front ocelli were correctly noted, would appear to be closely allied to it and might even be thought to be a plain red variety, were not that species very constant in its color markings, the longitudinal vittæ being very characteristic

Emplectonema Stimpson

Prodromus, in Proc Philad Acad. Nat Sci, vol ix, p. 164 [20] 1857.

Amphiporus Œrsted, Kroyer's Tidds., iv, p 581, 1844, (? *non* Ehr, *non* McIntosh)

Nemertes McIntosh, Nemerteans, p 176, 1873 (*non* Cuvier, 1817, *non* Œrsted, 1844, *non* Diesing, 1850, *nec* White, 1850)

Macronemertes Verrill, Amer. Jour. Sci., vol. vi, p. 439, 1873.

Body much elongated in extension, sometimes almost filiform, very contractile, rounded or a little flattened. Head not very distinctly defined; in some cases with a pair of longitudinal or oblique, shallow, submarginal fossæ on the upper side; in other cases (*E. gracilis*) without evident fossæ.

Ocelli variously arranged, often numerous and in several clusters, both anterior and cerebral.

Proboscis relatively small, especially the anterior portion, which is much shorter than in *Amphiporus.* Mouth usually (always?) separate from the proboscis-pore.

For this genus the earliest available name seems to be that given by Stimpson, who named as type *E. camillea* (Quatr. sp. = *E. Neesii* Œrsted sp.), which is also the type of the genus *Nemertes* of McIntosh. The latter name could not be retained in this sense, even if the genus had not received a prior name, for *Nemertes* had already been used for a genus of insects by White in 1850, in addition to its prior use for several distinct genera of Nemerteans. Had not Stimpson's generic name been available, *Macronemertes* would have been next in order.

Emplectonema giganteum Verrill

Macronemertes gigantea Verrill, Amer. Journ. Sci., vol. vi, p. 439, pl. 7, figs. 2, *a*, *b*, 1873, Expl. of Casco Bay, in Proc. Amer. Assoc. for 1873, p. 390, pl. 2, figs. 5, 6, 1873.

PLATE XXXV, FIGURE 2. PLATE XXXVIII, FIGURES 12, 12*a*.

Size large. Body much elongated, very contractile; in extension, subterete, a little depressed, thickest anteriorly, gradually tapering posteriorly, becoming very slender and considerably flattened toward the end. Integument very soft, secreting a large quantity of mucus. Head not distinct from the body and of the same diameter, obtusely rounded in front, with a terminal proboscis-pore; upper surface with two shallow, indistinct, sublateral, longitudinal fossæ, often becoming more distinct in alcohol; below with two rather indistinct, obliquely transverse grooves or fossæ.

Ocelli numerous, but not very distinct, because deeply buried in the integument; they are numerous, arranged in four or more clusters; a pair of large oval or subtriangular clusters on the anterolateral border of the head, each of which may be divided into an upper and a lower group, the upper part running backward; a pair of smaller lateral clusters farther back; and a pair of small rather indistinct clusters on the dorsal surface, between the longitudinal fossæ.

Color, when alive, deep salmon or bright orange-red, flesh-color below.

Length of the largest examples, 2 to 3·5 meters, or about 7 to 12 feet, in extension; diameter, anteriorly, 6 to 8^{mm}, or ·30 of an inch.

When preserved in alcohol this species soon loses all its color, contracts greatly in length, and becomes quite hard; sometimes the body is considerably flattened, but in most cases it retains its characteristic terete form except toward the posterior end. The head often shows the shallow, dorso-lateral, longitudinal fossæ (not slits) and the two large anterior groups of ocelli can usually be seen indistinctly as dark rounded patches beneath the thick outer integument. The small proboscis is often protruded a short distance, its pore being then rather small and slightly below the tip of the snout. The mouth is not visible in the preserved specimens, but my original sketches, made from life, show what I then supposed to be the contracted mouth beneath the head, distinct from the proboscis-pore.

In some horizontal sections of the head the anterior ocelli form an upper pair of transverse groups nearer the front than the sides of the head, while two smaller clusters, lower down in front, seem to be nearly separate from the upper ones. In some specimens these large anterior groups are formed of four or five transverse horizontal rows, of which the upper row runs back to a small lateral cluster of ocelli. The œsophagus has a large plicated anterior portion in the head. The mouth appears to open decidedly behind the proboscis-pore.

In sections of the body the intestine, blood-system, and muscular layers are nearly as in *Amphiporus*, but the muscular layers are unusually thick.

One specimen, taken August 12, 1878, contained large eggs, arranged in about six rows of sacs, above and at the side of the intestine, on each side. The armature of the proboscis has not been observed, but in other respects the proboscis agrees with that of the allied species; the length of the anterior region is about twice the diameter of the body; the posterior portion is long and slender.

Off Cape Elizabeth, 69 fathoms, soft mud, August 12, 1878; Gulf of Maine, 88 fathoms, mud, station 45, 1874; off Martha's Vineyard, 192 fathoms, fine sand and mud, station 869, 1880; off Martha's Vineyard, 229 fathoms, sandy mud, station 925, 1881; off George's Bank, 852 fathoms, gray mud, station 2531; off Block Island, 156 fathoms, fine mud and sand, station 2537; off Block Island, 181 fathoms, fine sand, station 2544, 1885. (U. S. Fish Commission).

Family, Drepanophoridæ Verrill, nov.

Amphiporidæ (pars) authors

Proboscis-sheath provided with cæcal appendages. Central armature of proboscis a lamelliform plate bearing a number of small stylets on its edge. Lateral stylet-sacs more than two; often numerous, containing small nail-shaped stylets

Drepanophorus Hubrecht

Body and head nearly as in *Amphiporus;* mouth-opening separate from the proboscis-pore. Proboscis large. Musculature of the body-wall as in *Amphiporus.*

Drepanophorus Lankesteri Hubrecht

Voyage of the Challenger, vol xix, pp 18, 50, pl i, fig 22, pl ix, figs 1 2, 10, pl x, figs 2, 4; pl xii, fig 5; pl xiv, figs. 9, 10, pl xv, fig 13, 1887

This species was described from alcoholic specimens, destitute of the proboscis. Its external features are, therefore, entirely unknown. Its anatomy was, however, carefully worked out by means of sections.

It is peculiar in having numerous well marked transverse nervous commissures connecting the lateral nerve-trunks anteriorly.

The cæcal appendages of the proboscis-sheath are also unusually well developed, with thicker walls than in most species, and they sometimes anastomose distally.

Ocelli are present, but their arrangement was not stated. Genital sacs are numerous, apparently in four rows, subventral.

For other details reference should be made to the original description and figures.

Off Nova Scotia, near Le Have Bank, 45 fathoms.

I have observed a single, small, and probably immature, specimen of Drepanophoridæ on the New England coast, but do not deem it wise to name it. This was translucent yellowish white in color.

Order II, ANOPLA.

Anopla Max Schultze, 1852; McIntosh.

Proboscis unarmed, long, slender, tubular, and not divided into three distinct regions; its walls may contain three to five layers; inner surface, when retracted, papillose.

Head with or without lateral slits or ciliated pouches.

Ocelli variously arranged; often wanting.

Mouth ventral, situated behind the ganglions.

The muscular walls of the body often consist of three layers: outer longitudinal, middle circular, and inner longitudinal (Pl. xxxix, figs. 17 to 21). In some cases the outer longitudinal layer is lacking (figs. 15 and 16).

Two or three main vascular trunks; the vessels generally not so well defined as in the Enopla, and often having in part the character of wide lacunæ, especially anteriorly.

Œsophagus entirely behind the brain, usually large, long, plicated, and surrounded by a vascular network, or by lacunæ. (Pl. xxxix, fig. 22, *r*, *r*).

Lateral nerve-trunks arise from the outer sides of the lower ganglions, and are situated between the muscular layers of the body-walls, but they vary in position in the different families. Usually there is a nervous plexus outside of the circular muscular layer. (Pl. xxxix, figs. 17, 20, *n*).

The species are almost all marine; a few inhabit brackish water.

Suborder I. RHAGADOCEPHALA Diesing, 1850 (emended)

Schizonemertini Hubrecht, Carus, Fauna Med., p. 160.
Schizonemertea Hubrecht, Voy. Challenger, xix, p. 37

Head with a deep, longitudinal, ciliated slit, or fossa (probably olfactory in function), on each side, terminating posteriorly in a deep pit or duct running inward to the posterior ganglions. (Pl. xxxix, fig. 22, *f*, *d*, *d'*).

Mouth large, behind or opposite the posterior ends of the lateral slits and cephalic ganglions. (Wood-cut 8).

Lateral nerve-trunks situated between the outer longitudinal and the circular muscular layers of the body-wall. (Pl. xxxix, figs. 19 to 21). A median dorsal nerve is also usually distinctly developed.

Three large, longitudinal, vascular trunks, which are usually connected by numerous transverse vessels around the intestine, especially posteriorly.

Œsophagus large, prolonged backward, plicated, and provided with a vascular system, probably having a respiratory function. (Pl. xxxix, figs. 20, 22).

Many of the species of this group develop directly from the eggs, without a marked metamorphosis, but certain species of *Micrura* (perhaps all) have a peculiar, free-swimming larval form known as *Pilidium* (Pl. xxxix, figs. 1 to 6, and wood-cut 7). The embryology of the closely related genus, *Cerebratulus*, is apparently unknown.

The species are almost exclusively marine and are found in deep water as well as between tides. Many are fossorial in their habits,

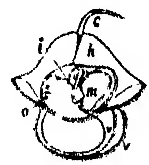

Fig. 7. Pilidium of *Micrura*, much enlarged: *c*, apical cilium, *h*, cephalic lobe, *m*, mouth; *i*, intestine, *v*, bands of cilia, *o*, young nemertean developing in the interior, showing its head with two ocelli.

living in sand or mud, or beneath stones. Some of the large flat species of *Cerebratulus* leave their burrows and swim with an undulatory, eel-like movement at the surface of the sea at night.

Family, Lineidæ McIntosh.

Body simple, generally much elongated in extension, very contractile, usually thickest in the region of the œsophagus, and becoming

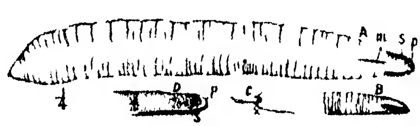

Fig. 8 *Lineidæ.* A, *Cerebratulus luridus*, ventral side, *m*, mouth, *s*, one of the olfactory slits or cephalopori; *p*, proboscis-pore. B, head of the same, side view C, tail, *x*, anus D, head of *Lineus* viridis, young, enlarged, *s*, one of the cephalopori; *p*, proboscis-pore.

more or less flattened farther back, where the saccular appendages of the intestine and the reproductive glands occupy the sides. Head simple, with elongated lateral olfactory slits or cephalopori.

Lineus Sowerby, 1806.

Lineus Sowerby, British Miscel, p 15, pl. 8, 1806

Borlasia Oken, Lehrbuch, p. 365, 1815; Blainville, Dict Sci. Nat, 57, p. 575, 1828, Johnston, Catal., p. 21, 1865.

Nemertes Cuvier, Regne Anim., vol. iv, p. 37, 1815; Dies (*pars*), op cit, p 264.

Lineus Œrsted, Naturh. Tidsskr., iv, p. 576, 1844.

Meckelia (*pars*) Diesing, Syst. Helm., vol. i, p 265, 1850.

Notospermus Diesing, op cit., vol. i, p. 260.

Lineus Stimpson, Prodromus, p. 160, 1851.

Cerebratulus (*pars*) Stimpson, Prodromus, p. 160, 1857.

Poseidon Girard, Proc. Boston Soc. Nat Hist, iv, p. 185, 1852

Nemertes Verrill, Invert. Vineyard Sound, etc., 1873.

Body very contractile, in extension elongated, slender, tapering, and often attenuated toward the posterior end, rounded or slightly depressed anteriorly, generally somewhat broader and more depressed in the middle region, but without the conspicuous flattening back of the œsophageal region seen in *Cerebratulus*. No anal papilla. Head elongated, not very distinctly defined; often a little wider than the neck, but not constantly so. Lateral slits elongated and deep, running close to the terminal proboscis-pore, but usually not joining it. Mouth, in ordinary states, rounded or elliptical and not very large, but capable of great extension when feeding. Ocelli small, usually arranged in a simple row along the lateral margins of the head, sometimes absent.

The several European species of this genus have been referred by authors to a great number of different genera, of which I have indicated only a part. The first three names cited in the synonymy were all given to the same species (*L. marinus* = *L. longissimus*) of Europe and are, therefore, exact equivalents. The two later names should, therefore, have been dropped entirely from the nomenclature of the group. Unfortunately several different writers have tried to restrict both *Borlasia* and *Nemertes* to groups entirely different from that to which they were originally given, and have thus introduced great confusion. Each attempt of this kind has, hitherto, been a failure for in most instances the new groups thus named have been found to have had other and earlier names. One of the latest reapplications of *Nemertes* to a newly constituted group was by McIntosh (Nemerteans, p. 176). He applied it to a genus of *Enopla*, in a wholly new sense. *Nemertes* of McIntosh, 1879, is, however, antedated by *Nemertes* of White, 1860, applied to a Crustacean, and therefore it could not be retained, even if the nemertean genus, so named, had not already received other names.

The use of *Borlasia* by McIntosh, in a wholly new sense, seems also to be untenable.

Lineus viridis (Fabr.) Johnston.

Planaria viridis O. Fabricius in O. F. Muller, Zool. Dan. Prod., 2684, 1776; O. Fabricius, Fauna Groenlandica, p. 324, 1780; Müller, Zoölogia Danica, ii, p. 35, pl. 68, figs. 1 to 4, (from Greenland specimens sent by Fabricius to Müller).

Planaria Gesserensis Müller, Zool. Danica, ii, p. 32, pl. 64, figs. 5 to 8, 1788.

Nemertes olivacea Johnston, Mag. of Zoöl. and Botany, vol. i, p. 536, pl. 18, fig. 1, 1837; Diesing, Syst. Helm., i, p. 273, 1850.

Nemertes obscura Desor, Boston Journal of Natural History, vol. vi, pp. 1 to 12, plates 1 and 2. 1848 (embryology).

Polia obscura Girard in Stimpson's Marine Invertebrates of Grand Manan, p. 82, 1853 (no description).

Nemertes viridis Diesing, Sitzungsberichte der kais. Akad. der Wissenschaften, vol. xlv, p. 305, 1862.

Borlasia olivacea Johnston, Catalogue British Non-parasitical Worms, p. 21, pl. 2b, fig. 1, 1865; McIntosh, Trans. Roy. Soc. Edinb., vol. xxv, pt. ii, p. 371, 1869.

Lineus viridis Johnston, Catal., pp. 27, 296, 1865.

Nemertes viridis Verrill, Marine Invert. of Vineyard Sound, etc., p. 334 [628], 1873.

Lineus Gesserensis McIntosh, Hist. British Annelida, Part I, Nemerteans, (Ray Society) p. 185, pl. iv, fig. 2, pl. v, fig. 1, (red var.), pl. xviii to xxii, (anatomy), pl. xxiii, (green var., embryology), 1873.

Lineus viridis Verrill, Check List Marine Invert., p. 12, 1879; Notice of Recent Addit. to Mar. Invert., Part I, in Proc. National Mus., ii, p. 185, 1879.

PLATE XXXVII, FIGURES 5 to *5b*; PLATE XXXVIII, FIGURES 6 to *6d*; PLATE XXXIX, FIGURES 18, 22.

Body soft, very contractile and changeable; in full extension elongated and moderately slender, in large examples six to eight inches long and about one-fifth of an inch in diameter; usually thickest in advance of the middle, tapering gradually to the rather slender caudal portion, and decreasing less toward the head; not unfrequently the body is dilated in two or more places at the same time, the swollen parts moving continually; in extension the body is usually somewhat flattened, but the dorsal surface is decidedly convex and the sides well-rounded; it is often crossed by faint, light-colored, irregularly spaced wrinkles. In contraction the body becomes short and thick, oblong, swollen and almost saccular at times.

Head, in extension, rather large, depressed, usually wider than the neck, short, ovate-spatulate, or elongated, according to the degree of extension; the snout is blunt, often emarginate, and bears three small ciliated papillæ; proboscis-pore terminal, rounded, or in the shape of a short vertical slit; lateral fossæ long and very deep, with wide, thin, pale margins, above and below, the anterior ends of the slits reaching close to the proboscis-pore.

The ocelli are arranged in a simple row on each side of the head, close to the edge of the dorsal pigmented region; they vary in number and size according to the age, the large specimens often having six or eight on each side, while the small ones have but three or four, and the very young ones have only a single pair; usually the anterior ocelli are slightly larger than the others.

The mouth is situated opposite to, or a little behind, the posterior ends of the lateral fossæ; it is ordinarily small and elliptical, with a distinct, lighter colored border, but it is capable of great dilation

when the creature is engaged in swallowing some annelid nearly or quite as large as itself.

The color, in life, is variable; the most common variety is dull green, or olive green, varying to dark smoky green or greenish black, darkest anteriorly, and with the under surface and caudal portion somewhat paler; region of the cephalic ganglions and lateral pits usually reddish; front and margins of head pale or whitish; on many specimens faint pale transverse lines or rings can be seen, if carefully examined; at times a row of small whitish spots, corresponding to the genital pores, can be seen on each side. Other specimens occur, often living with green ones, in which the general color of the body is brown, greenish brown, reddish brown, or clear red with the margins of the head and lower surfaces flesh-color or reddish.

Some of these forms differ so much in appearance from the common dark green variety that it would be convenient to distinguish them by variety names, using, in this sense, some of the numerous names applied by the early writers when they were supposed to be distinct species, viz:

Var. *olivaceus* (Johnston). The typical green and olive-colored variety.

Var. *fuscus*. The brown and reddish brown variety.

Var. *rufus* (Rathke). The distinctly red variety.

Var. *obscurus* (Desor). The smoky green and blackish variety.

Specimens intermediate in color between all these are, however, of frequent occurrence.

The length, in extension, is sometimes 150^{mm} to 200^{mm}; the diameter 2^{mm} to 4^{mm}; in contraction the body becomes much shorter and stouter, large specimens often being only 30^{mm} or 40^{mm} long and 4^{mm} to 6^{mm} broad.

In alcoholic specimens the body is usually thickened and rounded anteriorly, more slender and somewhat flattened farther back, often acute at the posterior end; head obtusely rounded or sub-truncate, with a small terminal proboscis-pore and two lateral slits, which are short and extend forward very near to the proboscis-pore. Mouth small and round, situated slightly behind the posterior ends of the lateral slits; ocelli not apparent. When placed in alcohol the body usually contracts so violently that it breaks up into segments, especially posteriorly, and the proboscis is often completely ejected.

The extruded proboscis is long, slender toward the base, clavate toward the end, the terminal portion transversely wrinkled.

This common littoral and shallow water species is found on the American coast from Long Island Sound to Labrador, Cumberland Gulf, and Greenland. It is also common on the coasts of Great Britain as far south as the Channel Islands (McIntosh), and on all the northern coasts of Europe.

South of Cape Cod, I have collected it near New Haven, Conn., and at the Thimble Islands; Noank, Conn.; Newport, R. I.; Wood's Holl, Mass.; and at various other localities. North of Cape Cod it is more abundant and larger. Among the localities where I have taken it are Provincetown and Barnstable, Mass.; Salem and Gloucester, Mass.; Casco Bay; Mount Desert Island; Eastport, Me.; Grand Menan Island; Halifax, N. S.; Gulf of St. Lawrence, etc.

It is particularly abundant and large at Eastport, Me., and at all localities about the Bay of Fundy, where the shore is composed of rocks.

This species is active and restless in confinement. It creeps rather rapidly and is prone to climb out of the water and perish by drying up. It is a voracious feeder and lives largely upon annelids. I have observed it in the act of swallowing a full grown scaly annelid, (*Lepidonotus squamatus*), which was considerably greater in diameter than the thickest part of its own body. A specimen of this kind, with the *Lepidonotus* half swallowed, is preserved in the museum of Yale University.

The eggs are deposited in great abundance on our shores under stones near low-water mark, in midsummer. They are contained in more or less cylindrical masses of a translucent, dull greenish, jelly-like substance, made up of numerous capsules, (Plate XXXVIII, fig. 6c). These cylinders are usually from 3^{mm} to 5^{mm} in diameter, and 40^{mm} to 50^{mm} in length, and are usually coiled in a spiral or ring-like form. The eggs are in several rows. In those clusters taken at one date, in July, at Eastport, Me., I have found eggs in all stages of development, while in some of them the recently hatched young were still present. (Pl. XXXVIII, fig. 6*d*).

I have adopted the name, *viridis*, given to this species by Otho Fabricius, who communicated the first published descriptions and figures to Müller, as stated both by him and by Müller. That this is the species observed on the shores of Greenland and described by Fabricius there can be no reasonable doubt. His brief description is quite as correct and characteristic as the descriptions of such animals were wont to be at that time, and his figures, published by Müller in the Zoölogia Danica, represent the worm fairly well when

partially contracted; nor could they be referred to any other Greenland species.

The lateral slits of the head of this species are spoken of on p. 325 of the Fauna Grœnlandica, and are also distinctly shown in the figures. Fabricius speaks of his *viridis* as common on the shores of Greenland among the roots of algæ. I have personally examined good specimens of this species recently taken on the coast of Greenland in the same situations. There can be no doubt of their identity with the true *viridis*. Therefore there is not the slightest reason why his characteristic name should not be used, in preference to *Gesserensis*,* of much later date.

Although the latter name has been adopted by many recent writers on European nemerteans, the ordinary rules of priority, as well as justice to the very meritorious author of the Fauna Grœnlandica, should compel a change in this respect.

Fabricius and Müller, in the same works, described another Greenland form under the name of *rubra*. I am of the opinion that this was simply the red variety of *L. viridis*, for the two varieties occur together everywhere on the northern coast of America. Levinsen, however, has referred the *rubra* to *L. sanguineus*, and has given the latter as a Greenland species. If both species actually inhabit Greenland his view may be correct, for there is nothing in the original description to indicate that it belongs to one rather than to the other of these two species, if it really belonged to either.†

Indeed these two reputed species are so much alike that I am myself in doubt whether they are really distinct. There is no special diagnostic character given by McIntosh unless it be the somewhat narrower head in *L. sanguineus*. The shape of the head in this genus is so changeable and variable that, in practice, little reliance can be placed upon this as a diagnostic character. The ocelli are supposed to differ slightly in size and number, but they also vary in both forms. Hence it seems to me not improbable that a more extended study of the variations will compel us to consider *L. sanguineus* only a lighter red variety of *L. viridis*. In this article I have, however, followed most European writers in keeping them separate, although I confess that with scores of living specimens of both

* Levinsen, in his recent paper on the Turbellaria of Greenland, also records the typical form, under the name of *L. Gesserensis*, as a native of that coast.

† Fabricius mentions neither ocelli nor cephalic slits in this species. Therefore it may not have been a *Lineus*. The necessary doubt concerning its true relations should prevent the application of the name to any species.

forms before me, I have always found it difficult to draw any clear line of separation between them

Lineus sanguineus (Jens Rathke)

Planaria sanguinea Jens Rathke, Skrivter af Naturhist Selsk., vol v, i, p 83, 1799
Planaria octoculata Johnston, Zool Jour., vol iv, p 56, 1829
Nemertes (Borlasia) octoculata Johnston, Mag Zool and Bot., vol i p 537, pl 18, fig 2, 1837, Œrsted, Kroyer's Naturhist Tidss., iv, p 579 in note, 1837
Nemertes sanguinea Œrsted, Entw Plattw., p 92, 1844
Borlasia octoculata Johnston, Catalogue Brit Mus., pp 21, 287 290, pl iib, fig 2 2*, 1855
Lineus sanguineus McIntosh British Annelids, part 1 Nemerteans, p 188, pl v, fig 2, 1873

PLATE XXXVIII, FIGURES 10, 10*a*.

Body strongly convex or well rounded above, flatish beneath, rather long, in extension often 8 to 10 inches long and .25 inch broad, but it is capable of contracting to less than one-fourth this length, and then becomes about .35 of an inch in diameter. Head elongated, usually not so wide as the body, often acute in front when extended, but it changes much in form and may become much shorter and obtuse in contraction; lateral cephalic slits, moderately long and deep, bordered by narrow pale lips, above and below Ocelli small, but very distinct, blackish, usually 4 to 8 in a row on each side, arranged at the upper margin of the white lateral borders of the head. Mouth rather large, usually round or oval, with corrugated white lips, but capable of great extension when swallowing large prey.

Color of body, above, dark red, bright red, or clear reddish brown, usually darker medially; beneath, pale salmon, flesh-color, or light yellowish red; snout and margins of head whitish; the red color of the middle of the head slightly emarginate or notched at its anterior end.

Eastport, Me., at Dog Island, low-water, under stones, 1868, (No. 2). Also taken at various other localities at Eastport and Grand Menan, between tides, in 1870 and 1872, common.

Under *L. viridis*, on a previous page, I have spoken of the close relationship of the red variety of that species to *L. sanguineus*, and have given reasons for doubting the status of this as a distinct species—at least as they occur on our northern coasts. It may be possible that we do not have the real European *L. sanguineus*, but we have an abundance of specimens that agree in all respects, so far

as I can see, with the descriptions and figures given by McIntosh and others.

The character upon which McIntosh puts the most stress is the greater narrowness of the head, said to be chiefly due to the narrower lips of the cephalic slits in the present species, as compared with *L. viridis* (*Gesserensis*). But as the length and breadth of the head and of the margins of the slits are constantly changing during the motions of the living worms, it is not easy to make sure of such differences. The lighter and brighter red color of the body, and the greater distinctness of the ocelli in *L. sanguineus* are also supposed to be characteristic.

It is found chiefly under stones from half-tide to low water mark, and at moderate depths (1 to 25 fathoms) on stony and muddy bottoms. Many specimens are often found living gregariously, curled up together, under one stone.

Lineus socialis (Leidy) Verrill

Nemertes socialis Leidy, Marine Invert. Fauna of Point Judith, R. I., and New Jersey, p. 11 [143], 1855; Verrill, Invert., Vineyard Sd. etc., p. 334 [628].

Lineus communis Van Beneden (?), Verrill, Notice of Recent Addit. to Mar. Invert. Part I, in Proc. National Mus., ii, p. 185, 1879.

PLATE XXXVII, FIGURES 8, 8*a*; PLATE XXXVIII, FIGURES 7, 7*a*.

Body very long and slender, subterete, attenuated posteriorly, in full extension almost linear, up to 8 to 10 inches long, with the diameter about .04 inch. Head very long, flattened, obtuse; lateral cephalic slits very much elongated. Mouth placed far back from the front of the head. Ocelli very small, often obscured by the dark color of the head, in large specimens four to six or more in a row on each side of the head, the front pair larger than the others and usually separated by a slightly greater interval; very young ones have only a single pair. Color, above, usually dark olive-green, greenish brown, greenish black, or smoky brown, and more rarely reddish brown, the anterior parts often darkest; indistinct, rather distant, pale transverse lines are often present, and occasionally there is a darker median dorsal stripe; front margin of the head paler and slightly translucent; lower surface of the body usually similar in color to the back but of a paler shade, most frequently dull green or greenish ash.

Length of large specimens, in extension, 250^{mm}, diameter 1^{mm} to 5^{mm}.

This is a strictly littoral species. It is common from New Jersey to the Bay of Fundy. It occurs abundantly and usually gregarious-

ly under stones, among living mussels, between the roots of grasses and algæ, etc., from near low-water mark nearly up to high-water mark of medium tides. I have collected it at Great Egg Harbor, N. J.; New Haven, Conn.; Noank, Conn.; Newport, R. I.; Wood's Holl, Mass.; in the harbors of Provincetown, Barnstable, Salem, and Gloucester, Mass.; Portland and Eastport, Me., etc.

This species is very gregarious, a large number usually living coiled up together in a tangled mass, from which, however, the individual worms can easily disengage themselves when disturbed. It occurs nearly up to high-water mark where other nemerteans are not found.

Superficially this species resembles, in color and general appearance, the young of *L. viridis* (dark green variety), but it is relatively much longer and more slender, and has a much longer and narrower head, with decidedly longer lateral slits, and the mouth is placed much farther back.

Lineus arenicola Verrill.

Tetrastemma (?) *arenicola* Verrill, Invertebrate Animals of Vineyard Sound, etc. p. 335, pl. xix, fig. 98, 1873.

PLATE XXXVIII, FIGURES 5, 5*a*

Body subterete, long, slender, slightly depressed, of nearly uniform width; the head is very versatile, usually sub-conical or lanceolate, flattened, occasionally becoming partially distinct from the body by a slight constriction at the neck. Ocelli four, those in the anterior pair nearer together. The lateral fossæ are long, and deep slits on the sides of the head. Mouth small, often sub-triangular, situated just back of the posterior ends of the lateral fossæ. Body deep flesh-color or pale purplish.

Length about 100^{mm}, in extension.

Savin Rock, near New Haven, Conn., in sand at low-water mark.

This species has not been taken except in the original locality. It appears to be very rare in our waters. Possibly it is a southern species that does not ordinarily live so far north.

Lineus pallidus Verrill

Lineus pallidus Verrill, Notice of Recent Addit. to Mar. Invert., Part I, in Proc. National Mus., ii, p. 186, 1879

PLATE XXXVII, FIGURES 9, 9*a*.

Body long and very slender in extension, subterete, attenuated posteriorly. Head elongated, usually obtuse and wider than the

body, but very changeable. Ocelli absent. Lateral (cephalic) fossæ long and deep. Mouth situated far back from the anterior end. Color usually whitish or pale ocher-yellow, usually becoming reddish toward the head, and with a rather indistinct pale dorsal line; anteriorly there are usually two pale dorsal spots in front of which the head is yellowish.

Length, in extension, 100^{mm}; breadth 0·5 to 0·75^{mm}.

Off Cape Ann, Mass., 45 fathoms, mud, 1878.

Lineus dubius Verrill

Lineus dubius Verrill, Notice of Recent Addit to Mar Invert., Part 1, in Proc National Mus., ii, p, 186, 1879

PLATE XXXVII, FIGURES 4, 4*a*.

Body very slender in extension, and attenuated posteriorly. Head elongated, narrow, usually pointed; lateral slits of moderate length; ocelli *white*, inconspicuous, forming a lateral row of about twelve, extending back on each side of the head beyond the posterior ends of the lateral fossæ, usually the four anterior ones on each side are separated by a little space from those that follow, but all are nearly in a simple row. Color, above, light green to dark olive-green.

Length of the largest specimens observed, 50 to 75^{mm}.

Gloucester, Mass., under stones, between tides, 1878.

Lineus bicolor Verrill, sp. nov

PLATE XXXVII, FIGURES 8, 8*a*, 8*b*.

Body rather small, in extension elongated, thickest and somewhat depressed in the middle, tapering to both ends, and decidedly attenuated posteriorly; sides rounded. Head elongated, flattened, rather wider than the neck, in usual extension. Lateral olfactory slits long and deep, with thin margins. Mouth usually elliptical, situated behind the ends of the olfactory slits. The ocelli are arranged in a simple row of about 4 to 7 on each side of the head, the front pair largest. Color, above, along each side of back a broad stripe of olive-green, yellowish green, or brownish green, separated by a median dorsal, well defined, broad stripe of pale yellow or yellowish white, usually becoming clear white on the head, where it expands and blends with a white frontal area in advance of the eyes; the margins of head are also white. Lower surface pale greenish or yellowish white.

Length in extension, 35 to 45^{mm}; diameter, 1 to 1.5^{mm}. Described from life.

Long Island Sound to Vineyard Sound, in 2 to 24 fathoms; Bartlett's Reef, 22 fathoms, 1874. Usually taken on shelly or stony bottoms among algæ, ascidians, and hydroids; common, especially in Vineyard Sound. The specimen figured was taken at Wood's Holl, July 14, 1875.

DOUBTFUL SPECIES.

Lineus truncatus (Hubr.) Verrill

Cerebratulus truncatus Hubrecht, Voyage of the Challenger, vol. xix, pp 37, 50, pl. 1, figs. 11, 12, 1887

This species was described from imperfect alcoholic specimens, so that its external form and color in life are entirely unknown.

In the contracted specimens the head is short, flattened, truncated in front; the cephalic slits are short and run forward close to, but do not join, the proboscis-pore; the mouth is small, rounded, and only a short distance back from the front.

Off Nova Scotia in 75 and 85 fathoms; also off Bermuda. (Challenger Exp.)

The small mouth, rounded body, and general appearances of the specimens, as figured, indicate that it belongs to *Lineus* or *Micrura*, and not to *Cerebratulus*, as here defined. There is nothing in the description to distinguish it from *Lineus viridis*, which often contracts into the same form.

Micrura Ehrenberg, 1830.

Micrura (pars) McIntosh, Nemerteans, p. 196.
Cerebratulus (pars) Hubrecht

Body, head, and proboscis nearly as in *Lineus;* body elongated, terete or somewhat flattened; the posterior regions usually not much flattened, nor very different in form from the region of the proboscis. Cephalopori or olfactory slits well defined. Ocelli sometimes present, but often wanting. Posterior end of the body provided with a median slender cirrus, above the anus.

This genus, as here defined, differs from *Lineus* in little else than the presence of a well marked contractile anal cirrus, which may often be distinguished even in alcoholic specimens. From *Cerebratulus*, which also has the anal cirrus, it differs in the form and muscular structure of the body posteriorly, which is not very flat and thin, nor adapted for swimming, as in the latter.

Some of the flat species included in this genus by McIntosh, I should, therefore, transfer to *Cerebratulus*, especially his *M. fusca* (*non* Fabr. sp.)

Hubrecht has united *Micrura* and *Cerebratulus* without regard to the form of the body and the muscular structure of the body-walls, which seem to me important characters, involving wide differences in habits.

The species of *Micrura* are fossorial in their habits and do not swim at the surface, so far as I have observed, and, indeed, the form and structure of the body are not adapted for swimming.

Some of the species of *Micrura*, if not all, have a Pilidium-stage in development. The embryology of many of the species has, however, not been traced. Nor have any of the several species of Pilidium-larvæ found on our coast been reared till the adult characters could be determined. On Plate XXXIX, I have figured two distinct kinds of these larvæ that are common at Wood's Holl, Mass., in summer. One or both probably belong to some of our species of *Micrura*, but as the larval form of *Cerebratulus* is unknown, one of them may belong to that common genus. The young nemertean seen in the interior of one species (fig. 5, *m*), has already two distinct ocelli, which would indicate that it belongs to a species like *M. affinis*, which has ocelli when adult.

Micrura affinis Verrill

Poseidon affinis Girard in Stimp., Marine Invert. of Grand Manan, p. 28, 1853.
Nemertes affinis Verrill, Amer. Journ. Sci., vol. vii, pp. 39, 412, 1874; Proc. Am. Assoc., for 1873, pp. 351, 363.
Micrura affinis Verrill, Proc. U. S. Nat. Mus., vol. ii, p. 186, 1879; Check List, Invert., p. 12, 1879.

PLATE XXXVI, FIGURE 1; PLATE XXXVII, FIGURES 6, *6a*.

Body elongated in extension, somewhat depressed, but with rounded sides, of nearly uniform breadth through most of the length, but somewhat tapered posteriorly, and terminated by a slender, pointed, pale anal papilla or cirrus, about one-half as long as the diameter of the body. Head scarcely wider than the neck, elongated, flattened, usually obtusely rounded anteriorly, but changeable. Lateral olfactory slits long and deep, with thin white margins in front, uniting with the proboscis-pore. Mouth of moderate size situated opposite the ends of the slits. Ocelli rather large, black, conspicuous, variable in number, forming a single row, usually of four to six on each side at the edges of the white marginal areas; the front ocelli are

usually distinctly larger than the others. Color, above, usually clear bright red, varying to dark red and reddish brown, rarely to greenish brown; often crossed by indistinct, transverse, pale lines, as in *Lineus viridis*; front and margins of head white; under surface light flesh-color or pinkish, often showing by translucency the intestinal cæca or pouches along the sides in the form of transverse gray blotches.

Length up to 125 to 150^{mm}; diameter, 2 to 4^{mm}. Described from life.

Very common from off Cape Cod and Massachusetts Bay to Nova Scotia, in 8 to 150 fathoms or more, on shelly and stony bottoms. It is particularly common in the Bay of Fundy, the harbor of Eastport, Me., and the other cold waters of that region, where it is also often found at low-water mark under stones. It has also been frequently dredged in 12 to 50 fathoms south of Cape Cod, and off Nantucket and Martha's Vineyard, in the cold area.

This species, in some of its red and brown varieties, closely resembles the red and brown varieties of *Lineus viridis*, from which it cannot be distinguished when living without a careful examination. The presence of the caudal cirrus is easily diagnostic, when the specimen is perfect, but when mutilated, as often happens, the difficulty is much increased. The ocelli in this species are usually larger and more distinct than in *Lineus viridis*.

Micrura dorsalis Verrill, sp. nov.

PLATE XXXVIII, FIGURES 4, 4*a*.

Body depressed, rather large and thick, length up to 6 inches in ordinary extension; in contraction it becomes short and thick, and may even contract itself into a ball; the margins are well rounded and the body tapers toward both ends. The anterior region of the body for about a sixth to a tenth of the whole length, often becomes in partial contraction rounded and narrower than the rest of the body. Head obtusely pointed or bluntly rounded in front, not distinct from the body and of the same breadth. Cephalopori moderately long, somewhat oblique longitudinal slits on the sides of the head, extending nearly to the proboscis-pore. Ocelli, none. Mouth small, rounded, nearly opposite the hind end of the cephalopori.

Color pale ocher-yellow with an orange tinge anteriorly, with a darker medial stripe above and below, and having pale mottlings indistinctly showing through on each side due to the internal organs.

Length 160^{mm}; diameter 5^{mm}. Described from life.

The type-specimen, described above, as now preserved in alcohol, has a stout body, thickest anteriorly, tapering to the hind end, which terminates in a small, whitish caudal papilla. The sides are everywhere rounded. Head short, thick, subconical, blunt, not distinct from the body; proboscis-pore terminal, in the form of a short vertical slit; lateral cephalic slits moderately long, joining the proboscis-pore in front, so as to divide the tip of the snout into four parts. Mouth small, rounded, opposite the posterior ends of the cephalic slits.

Length in alcohol, 64^{mm}; diameter 3^{mm}; length of cephalic slits 3^{mm}.

Eastport, Me., at Clark's Ledge, extreme low-water mark, under stones, 1870.

Micrura rubra Verrill, sp nov

PLATE XXXVIII, FIGURES 3, *3a*, 9, *9a*.

Body moderately large, subterete and elongated in extension, up to 3 inches long, rather more slender posteriorly. Head obtuse or rounded in front; proboscis pore a vertical terminal slit; cephalic slits or cephalopori long and deep, in front joining the proboscis-pore so as to divide the tip of the snout into four small lobes; the slits extend back as far as, or beyond, the mouth, which is ordinarily a small elliptical opening. No ocelli.

Color, above, light orange red to bright red, indistinctly mottled along the sides with brownish red, due to internal organs.

Length 62 to 75^{mm} in extension; diameter $2{\cdot}5^{mm}$. Described from life. (No. 722).

In alcohol the specimens above described are much contracted, thick and short, stoutest anteriorly, tapered, but scarcely flattened posteriorly. Ovaries filled with eggs commence some distance back of the head. Cephalic slits moderately long and deep, joining the proboscis-pore in front. Prosboscis, as ejected, coiled in a spiral, moderately long and rather thick, tapering to both ends.

Off Casco Bay, July 16, 1873.

A curious specimen (Plate XXXVIII, fig. 3, *3a*), probably of this species, was taken in the Bay of Fundy. It had, apparently, been broken and was in the act of reproducing the hinder part of the body.

Body round, cylindrical in extension, very changeable in shape; posterior end abruptly narrowed into a small, round caudal portion terminating in a small papilla. Head obtusely rounded or obliquely

conical with an oblique lateral cephalic slit on each side; mouth small, opposite the posterior ends of the slits. No ocelli.

Color nearly uniform deep flesh-color. The salmon-colored ovaries show through slightly, especially posteriorly, as transverse spots.

Length about 25^{mm}; diameter $2·5^{mm}$.

Bay of Fundy, off Head Harbor, Campo Bello Island, 40 fathoms, mud, Aug. 27, 1870. (Catal. No. 117).

Micrura albida Verrill.

Micrura albida Verrill, Notice of Recent Addit. to Mar. Invert., Part I, in Proc. National Mus., ii. p. 186, 1879.

Body slender, thickest and nearly round anteriorly, gradually tapered and somewhat flattened posteriorly, with a small, slender caudal papilla. Head flattened, narrow, obtuse, narrower than the body. No ocelli. Lateral fossæ rather short, extending beyond the mouth, not conspicuous. Color whitish, or pale yellowish, often becoming light red toward the head; posteriorly often with grayish or clay-colored internal mottlings along the sides, due to the reproductive organs. Very sluggish in its motions.

Two specimens from 140 fathoms, off Cape Ann, apparently of the same species, were milk white above, with fine specks of opaque white, the ganglions showing as red spots; they had a narrow but distinct ring of blue around the body, behind the head.

Length, 50 to 125^{mm}; diameter 2·5 to 3^{mm}.

Common in the Gulf of Maine and Massachusetts Bay, on muddy bottoms, in from 30 to 140 fathoms.

It is sluggish in its movements and constructs translucent tubes of tough mucus.

Micrura inornata Verrill.

Micrura inornata Verrill, Notice of Recent Addit. to Mar. Invert., Part I, in Proc. National Mus., ii, p. 186, 1879.

PLATE XXXVII, FIGURE 7.

Body subterete, moderately elongated, thickest anteriorly or in the middle, gradually tapered to the somewhat flattened tail; caudal filament white, very slender and acute, sometimes as long as the diameter of the body, but usually less. Head obtuse, often as wide as the body or wider, somewhat flattened. Lateral fossæ long, deep, curved, extending to opposite the mouth, the latter not being very far back. No ocelli. Color above, bright cherry-red, varying to dark red, the middle of the head brightest; tail pale.

Length of largest specimens observed, about 75^{mm}; breadth, 1·5 to 2^{mm} in extension Described from life.

Massachusetts Bay and Gulf of Maine, 45 to 110 fathoms, mud.

Resembles the young of *Cerebratulus luridus* V., which occurs with it.

Cerebratulus Renier, 1804

Meckelia Leuckart, Breves Anim., p 17, 1828 (t Rathke), Diesing, Syst Helm vol i, p 266 1850

Serpentaria Goodsir, Ann Nat Hist, vol xvi, p 377, 1835

Cerebratulus (*pars*) and *Meckelia* Stimpson Prodromus, p 100, 1857

Cerebratulus McIntosh, British Annelids, Part I, Nemerteans, p 194 1873

Cerebratulus (*pars*) Hubrecht, Voy Challenger, vol xix, p 37, 1887 Carus, Fauna Medit, p 160

Body large, elongated, much flattened along the middle and posterior portions and adapted for swimming by having the margins produced and thin, mainly owing to the unusual development of the longitudinal muscular layers, which are greatly thickened, especially the outer layer, which, as seen in transverse sections, forms a more or less triangular band, much thicker than elsewhere, (Plate xxxix, fig. 19, *l*). Transverse muscular bundles running from the upper to the lower sides of the inner surface of the body-wall (fig 19, *t'*) are also unusually well developed so as to aid in giving an undulatory motion to the margin while swimming.

Anterior or œsophageal region large, with rounded margins (fig. 20). Cæcal appendages of intestine numerous and crowded, elongated, more or less forked and lobed at the outer ends, the divisions occurring partly horizontally, and showing well in sagittal sections.

Head versatile in form, usually without ocelli. Cephalic lateral slits or olfactory organs are large and deep. Mouth unusually large, oblong or oval, rather far back. Proboscis very long and slender; in section showing decussated muscular layers medially, above and below.

Anal papilla or cirrus often long and slender, delicate, contractile, often wanting owing to injury. It contains a continuation of the muscular layers of the body-wall.

Hubrecht has united *Micrura* to this genus, and in his report on the Nemerteans of the Challenger Exp. he proposes also to unite *Lineus* with it.

Such a wholesale massing together of these groups seems to me unnecessary and undesirable, and is, apparently, only thought of because of the difficulty of distinguishing the generic position of alco-

holic specimens—a difficulty that holds with quite as much force in many other groups of animals, which lose many of their characters by preservation in any known medium.

However, it seems to me that some of the large species referred to *Micrura* by authors really belong to *Cerebratulus*, especially those like *M. fusca* McIntosh (*non* Fabr. sp.)

The differences noted by McIntosh in the muscular layers of the proboscis appears to me of less importance than the special muscular structure of the body-wall which enables the species of *Cerebratulus* to swim actively at the surface, while the more slender and rounded species belonging to *Micrura* (restr.) and *Lineus*, so far as I have observed, are unable to swim, and do not voluntarily leave the bottom.

The broad, flattened form of the body with thin margins is the external expression of the internal musculature, adapting it to the undulatory swimming motion.

Cerebratulus lacteus (Leidy) Verrill.

Meckelia fragilis Girard, Nord Amer. Monatsb., 1851 (*non* Goodsir, sp.)

Meckelia lactea Leidy, Proceedings Academy Natural Sciences of Philadelphia, vol v, p. 243, 1851, (young); Verrill, Invertebrate Animals of Vineyard Sound, p 336 [630], 1873, (young), *non C. lacteus* Hubrecht, Mont sp.=*Lineus lacteus* McIntosh.

?*Meckelia Lizzie* Girard, Proc. Acad. Nat Sci Philad., vol. vi, p 366, 1854.

Meckelia ingens Leidy, Marine Invertebrate Fauna of Rhode Island and New Jersey, p. 11 (143), 1855; Verrill, Invertebrate Animals of Vineyard Sound, p. 336 [630], Plate XIX, figures 96, 96a.

PLATE XXXV, FIGURES 1, 1*a*; PLATE XXXVI, FIGURE 2; PLATE XXXVII, FIGURES 1, 1*a*, 1*b*; PLATE XXXIX, FIGURES 19, 20, 21.

Body flat, large and very long when full grown, sometimes becoming fifteen to twenty feet long and upwards of an inch in breadth, very contractile and changeable in length, breadth, and form. While swimming the body is turned up edgewise and thrown into many undulations and the motion resembles that of an eel, but is less rapid. The anterior part of the body for some distance back of the head is, in usual extension, narrower and thicker than the rest, with the margins rounded; the body then expands rather rapidly in breadth and at the same time becomes more flattened while the margins become thin and pale, and throughout the rest of its length the body continues thin and flat, gradually decreasing in breadth and thickness toward the posterior end, which is usually obtuse, or slightly emarginate, but occasionally, or when perfect, terminates in

a slender anal papilla. The posterior end is, however, seldom seen entire, owing to its extreme fragility and its tendency to disrupt itself when irritated. When disturbed the middle region of the body often contracts, while the anterior becomes thick and swollen.

The increase in breadth of the body and enlargement of the marginal regions marks the commencement of the crowded lateral lobes of the stomach and the genital organs, which can usually be seen through the translucent integuments; the cæcal lobes of the intestine usually appear as closely arranged, transverse, oblong spots, forming a regular row along each side, from their commencement nearly to the posterior end of the body, and usually having a slightly darker or more brownish tint than the central and marginal regions. The cæcal appendages, when seen from above or below, usually appear as simple, narrow, but often forked, and closely arranged lobes, but when examined in sagittal sections they are mostly lobed and forked horizontally. The genital organs are closely crowded between the cæcal pouches of the stomach, distally.

The head is exceedingly changeable in shape, according to its state of contraction or expansion, but is usually narrower and thinner than the adjacent part of the body. In full extension it is usually broad spear-shaped or rhomboidal, and more or less pointed at the apex, while marked lateral constrictions separate it posteriorly from the body, but in another moment it may contract to a broad rounded form, or it may even become deeply emarginate in front, with rounded lateral lobes, or it may change to a very narrow and elongated form with a sharp point. Ocelli are wanting.

The lateral cephalic slits are large and deep, extending the entire length of the head, and running forward close to and a little above the proboscis-pore, those of opposite sides not uniting together except by a very shallow furrow; they do not join the proboscis-pore, so that the snout is not four-lobed at tip, as in some allied species. Their margins are thin and mobile, often undulated or curled back so as to open the slits widely and expose the deep posterior pits, which, in life, are dull red within. Proboscis-pore large, terminal or subterminal.

Mouth very large, but variable in form as the head varies in shape, most frequently appearing as a long, narrow oval or oblong slit, its anterior end opposite the posterior ends of the lateral slits.

Proboscis exceedingly long, slender, round, whitish, and nearly smooth. When the worm is placed in alcohol or other irritating fluid the proboscis is usually ejected entirely without eversion (Pl.

xxxv, fig. 1*a*); in large specimens it is four feet or more long, and 3 or 4^{mm} in diameter at the large end.

Color of small and moderate-sized specimens is translucent milk-white, cream-color, pale flesh-color, and occasionally pale salmon or pale pink, with the margins paler and more translucent; larger individuals are generally deeper flesh-color, cream-color, light salmon or ocher yellow, and occasionally dull gray; the cæcal appendages of the intestine and the reproductive organs appear as a more opaque yellowish or pale brownish band along each side, near the pale margins; the lateral nerve-trunks are reddish.

Length of ordinary adult specimens, in extension, 500 to 1200^{mm}; breadth in middle 15 to 22^{mm}; some specimens are more than double these sizes.

Common, burrowing both in sand and mud at and above low-water mark, and in shallow water down to several fathoms in depth, from Florida to Massachusetts Bay, and locally found on the coast of Maine.

It is particularly abundant near low-water mark on the sheltered sandy shores of the New Jersey estuaries; Long Island Sound; Buzzard's Bay; Vineyard Sound; Cape Cod; and at Annisquam, Mass., north of Cape Ann I have taken a number of well grown examples at Quahog Bay, on the coast of Maine, where it is associated with a colony of other southern species. I have not found it in the Bay of Fundy, where it is replaced by a closely allied arctic species (*C. fuscus*). Its southern range is not well determined, but I have seen specimens from Fort Macon, North Carolina, and others from St. Augustine, Fla., and Charleston, S. C., (W. R. Coe).

The largest specimen hitherto obtained I personally dug from the sand at low-water mark at Great Egg Harbor, N. J., April, 1872. This one, when extended, was 22 feet long and nearly an inch in breadth, in the middle. It could contract, however, to less than 6 feet in length, becoming, at the same time, much broader, thicker, and firmer. This gigantic specimen is, apparently, the most bulky nemertean that has ever been described, though species of *Lineus* far exceed it in length.

When preserved in alcohol it contracts very firmly and shows very plainly the contrast between the form of the anterior and middle regions of the body, the latter being decidedly flat with thinner margins. The head takes various shapes.

In alcoholic specimens the mouth is usually large and open. Sometimes numerous small whitish papillæ, probably containing the

genital pores, can be seen a short distance from the margin, both above and below; sometimes there are several in each transverse row; at other times only two or three are visible.

In transverse sections the great thickening of the interior longitudinal muscular layer in the marginal areas is strongly marked. (Pl. XXXIX, figure 19.)

The earliest name of this species that can be retained is apparently *C. lacteus* (Leidy), which was given to the white specimens that I now regard as the young of this species. I have adopted this name for the species, notwithstanding that *Lineus lacteus* (Mont.) McIntosh is now referred to *Cerebratulus* by Hubrecht. That the latter belongs to *Cerebratulus*, as here defined, I do not think possible.

A large species (*C. Pocohontas*) from Charelston, S. C., very briefly described by Girard under the name of *Meckelia Pocohontas*,* appears to be very similar to our species in size (3 feet long), form, and color, but he states that the snout is split vertically [by the proboscis-pore], indicating that the cephalic slits join the proboscis-pore in front, so that the snout, as he states, is four-lobed at the tip, which is not the case in our species. *C. Lizziæ*, from the same place, described in few words, at the same time (op. cit. p. 367), agrees with our species in respect to the color, snout, and slits, and may be identical with it.

C. striolenta (*Leodes striolenta* Girard, loc. cit.) also from Charleston, appears to be a typical *Cerebratulus*, but it is a very distinctly marked species, having a pink body, longitudinally striped, and with dark longitudinal blotches on the head; margins pale; length six inches; no ocelli.

Cerebratulus Leidyi Verrill

Meckelia rosea Leidy, Proc. Acad. Nat. Sci. Philad., vol. v, p. 244, 1851; Verrill, Invert. of Vineyard Sound, etc., pp. 336, [630] 1873.

? *Renieria rubra* Girard, Proc. Acad. Nat. Sci. Philad., vol. vi, p. 366, 1854.

Cerebratulus roseus Verrill, Check List Invert., p. 12, 1879, (*non C. roseus* (D. Ch.) Hubrecht).

PLATE XXXVIII, FIGURES 2, 2*a*.

Body elongated, rather slender in extension, rounded in the œsophageal region, decidedly flattened and wider farther back, but not so much so as in *C. lacteus* and allied species, nor do the margins become so broad and thin. Caudal papilla of moderate length, slender, white, often absent, owing to injury.

*Proc. Acad. Nat. Sciences, Philad., vol. vi, p. 366, 1854.

Head versatile, in extension decidedly long and narrow, often narrower than the body, regularly tapered to the acute tip.

Mouth large, elongated, with slightly crenulated white lips; its anterior end is about opposite the posterior ends of the lateral slits.

Lateral cephalic slits long and deep, with thin, translucent margins, often curved back so as to show the large interior cavity; in front they run very close to the proboscis-pore, which, in contraction, appears as a sub-terminal vertical slit. Proboscis very long and slender, pale pink in color. No ocelli. Cephalic ganglions large, showing through the integument as dark red spots.

Color of body dull red, or rose-color, or pale purplish, somewhat lighter beneath; usually with a lighter colored median line, and a red spot in the head corresponding to the ganglions; front of head and mouth area whitish; the closely arranged cæcal lobes of the intestine often show through the integument, especially beneath, as a pale brown band along each side. These cæcal appendages are numerous, and many of them are divided into two or three lobes distally.

Very common, burrowing in sand near low-water mark, from New Jersey to Cape Ann, Mass. It is abundant near New Haven, Conn.; Thimble Islands and Noank, Conn.; Newport, R. I.; and Wood's Holl, Mass.

This is a more strictly littoral species than the preceding. It seldom occurs much below low-water mark. The mucus that it secretes is more tenacious than that of most species, so that captive specimens often cover themselves quickly with adherent sand.

This species is generally found associated with *C. lacteus*, from which it can easily be distinguished by its decidedly red color, and its narrower and more slender body, without the very thin margins. It is also a more sluggish species and seldom swims freely. It is prone to break itself in fragments when captured.

It is unfortunate that the name *roseus*, which applies so well to this species, cannot be retained on account of the much earlier named Mediterranean species. I have, therefore, given it a new name in honor of Professor Leidy, who first described it.

It is quite probable, however, that *C. rubra* (=*Renieria rubra* Girard, op. cit., p. 366, 1854) is identical with this species. Girard's description is too brief and indefinite to determine this question. He describes *C. rubra* as uniform brick-red, paler beneath, and as lacking eyes; length 5 to 6 inches. Its form was nearly as in the present species. It was from Charleston, S. C., on sand-flats at Fort Johnson.

Cerebratulus fuscus (Fabr.) Verrill.

Planaria fusca Fabr., Fauna Groenlandica, p. 324, 1780.

Meckelia olivacea Rathke, Beiträge zur Fauna Norwegens, p. 324, 1843 (from Acta Akad. Cæs. Leop. Carol. Nat. Cur., vol. xx, 1843).

Serpentaria fragilis Goodsir, Ann. Nat. Hist., vol. xv, p. 387, pl. 20, figs. 1 and 2, 1845.

Meckelia serpentaria Diesing, Systema Helm., vol. i, p. 266, 1850.

Gordius fragilis Dalyell, Pow. Creat., vol. ii, p. 55, pls. 6, 7, and 7 (*bis*), 1853.

Meckelia serpentaria Leuckart, Archiv für Naturges., ii, p. 187, 1859.

Serpentaria fragilis Johnston, Catalogue Brit. Mus., p. 28, 1865.

Cerebratulus angulatus McIntosh, British Annelids, part i, Nemerteans, p. 195, 1873.

Cerebratulus (?) sp. undetor. (*a*) Verrill, Report on Invert. Anim. of Vineyard Sound, p. 336 [630], 1874.

Cerebratulus fragilis (?) Jensen, op. cit., p. 85, 1878.

Cerebratulus grandis (Sars) Jensen, op. cit., p. 97, pl. 8, figs. 17–22.

Cerebratulus fuscescens Levinsen, Bidrag til Kundskab om Grönlands Turbellariefauna, p. 40 [202], 1879.

PLATE XXXVII, FIGURES 2 TO 2*c*.

Body large, stout, rounded for a considerable distance back of the head, and thence broad and much flattened to the posterior end, the edges thin and usually pale in color. Head very changeable in form, often broad lance-shaped, with acute snout, changing quickly to ovate, rounded, or even emarginate forms. Ocelli wanting. Mouth large, oblong. Cephalic slits large and deep, moderately long; they do not meet in front, nor run into the proboscis-pore, but lie in a higher plane. Anal cirrus slender, easily detached.

Color, above, dull ash-gray, greenish gray, slate-color, clay-color, grayish olive, or dirty brown, paler below, and with paler margins, within which, on each side, a red line, showing through the integument, marks the position of the large lateral nerves. Sometimes the back is mottled with lighter, and darker gray or slate; mouth surrounded by white, reddish at the anterior angle.

Length up to two feet or more. A specimen taken at Todd's Head, Eastport, Me., under stones at low-water, Aug. 19, 1870, measured 400^{mm} in length, when moderately extended; breadth, in middle, 12 to 14^{mm}, but it could contract to less than 100^{mm} in length.

This is a northern and arctic species. I have taken it at Halifax, N. S.; Grand Menan, N. B.; Eastport, Me., under stones and in sand and gravel near low water mark, and beyond in shallow water to 20 fathoms or more. South of Cape Cod it occurs in 15 to 45 fathoms on bottoms of sand and mud in the cold areas swept by the

arctic current, as off Gay Head, in 19 fathoms, and off Block Island, in 29 fathoms. It is also found on the coasts of Greenland, northern Europe, and Scotland.

This species usually lives in burrows under stones, in muddy or sandy places, at and below low-water mark, but when disturbed it swims readily and rapidly with vigorous eel-like undulations of the posterior flattened portion of its body, which is carried with the greater diameter vertical while swimming. In this habit it agrees with *C. lacteus* and several other large species, but it is, perhaps, more active and more vigorous than *C. lacteus*, and somewhat less liable to disrupt its body when captured. Like *C. lacteus* it is occasionally taken at night in surface nets, showing that it is nocturnal in its habits and voluntarily leaves its burrows and swims free at the surface.

After long preservation in alcohol the slate-color of the body and the white margins are often distinctly visible. In some alcoholic specimens the small and slender anal papilla is still preserved, but it is so fragile that it is generally lost during capture or in the violent contractions caused by the alcohol.

Our species is probably identical with the European species named *C. angulatus* by McIntosh, who supposed his species to be the *Planaria angulata* of Fabricius (Fauna Gronlandica). The latter is, however, our *Amphiporus angulatus*, as stated on a former page.

Formerly* I supposed that the Greenland species named *Planaria fusca* by Fabricius might be the brown variety of *Lineus viridis*, but a more careful study of his description, in which the absence of ocelli, the presence of lateral cephalic slits, the rounded form of the anterior, and the distinctly flattened form of the posterior part of the body are mentioned, has convinced me that the species he had in hand was the common dark-colored, large, northern *Cerebratulus*, which has received many later names. His statement that it lives in sand on the shores confirms this view. Moreover, this same *Cerebratulus* has been recently recorded from the Greenland coast and referred to the Fabrician species by Levinsen, as quoted above. He, however, adopts the later emended form of the name, quite unnecessarily it seems to me. Hence I have restored the original name, first given by Fabricius to this species.

* Proc. U S. Nat Mus, vol. ii, p. 185, 1879

Cerebratulus luridus Verrill.

Meckelia lurida Verrill, Report on Invert of Vineyard Sound, etc, p. 336 [630], 1873.

Cerebratulus luridus Verrill, Check List Invert, p 12, 1879

PLATE XXXVI, FIGURE 3; PLATE XXXVII, FIGURE 3.

Body large, rather stout, very changeable in form, broad, flat, thin posteriorly, where the lateral cæca and reproductive organs are developed; these diminish anteriorly and do not extend forward into the narrower, rounder, and thicker portion which occupies nearly one-fourth the whole length. Head very changeable, often separated from the body by a constriction; in expansion often spade-shaped, obtuse, or pointed. Lateral cephalic slits very long and deep; in front they are connected together by a shallow furrow, above the proboscis-pore. Mouth large, usually in the form of a long slot, commencing about opposite the posterior end of the lateral slits. Proboscis long and slender. Caudal papilla small, slender, acute.

Color reddish brown to dark olive-brown, chocolate-color, or purplish brown, darkest anteriorly, and with pale margins; the cæcal lobes of the intestine show through the integument as dull brownish or ocher-yellow transverse bars; usually there is a brown or reddish median dorsal line, and a pale ventral line. Some dark specimens are marked with several narrow lighter reddish or purplish longitudinal lines. Young specimens are usually reddish brown or liver-brown with paler snouts.

Length 150 to 250^{mm}; breadth 8 to 12^{mm}. Described from life, (No. 723).

Off Gay Head, 19 fathoms, soft mud, 1871; off Buzzard's Bay, 25 fathoms; and off Block Island, 29 fathoms, sandy mud, 1871; Casco Bay, 10 to 68 fathoms, 1873; Massachusetts Bay, in many localities, 1877, 1878, 1879, in 10 to 100 fathoms; Bay of Fundy; off Halifax, N. S., etc., common; off Martha's Vineyard, 192 fathoms, 1883. Numerous specimens of various sizes from 1 to 8 inches long were taken in Cape Cod Bay, in 15 to 21 fathoms, soft mud, Aug. 29, 1879. The larger ones were filled with eggs.

DOUBTFUL SPECIES.

Cerebratulus medullatus Hubrecht, Voyage of the Challenger, vol xix, pp. 39, 50, pl. xi, fig 10; pl. xii, figs. 9, 10, 1878.

PLATE XXXIX, FIGURE 17.

This species was described from a mere fragment, without head or tail. It is said, however, to differ from other species in the structure of the body-wall, which is thinner than usual.

The inner glandular layer of the integument and the inner basement membrane are wanting, as distinct layers, so that the outer glandular layer and its basement layer are in contact with the outer-longitudinal muscular layer. The median dorsal nerve, or nervous thickening, is also unusually large and distinct, being from one third to one-fourth as thick as the core of the lateral nerve-trunks.

Off Nova Scotia, in 85 fathoms.

This species is probably not a *Cerebratulus*, as here defined, but more likely belongs to *Lineus* or *Micrura*, and perhaps to some of the species described above.

Suborder II, GYMNOCEPHALA.

Holocephala Diesing, 1850, *non* Müll., 1835
Gymnocephalidæ Kefferstein, Zeitsch fur wiss Zool., xii, 1862
Anopla (*pars*) McIntosh, Nemerteans, p 203.
Palæonemertini Hubrecht; Carus.
Palæonemertea Hubrecht, Voy Challenger, xix, p 5, 1887
Palæonemertina Lang, Text-Book of Comparative Anat., p. 178, 1891.

Head without lateral slits, but sometimes having shallow transverse or oblique fossæ connected with small, ciliated (olfactory) pouches or ducts leading to the posterior ganglions; sometimes destitute of both fossæ and ciliated ducts. Mouth distinct, situated back of the ganglions.

Proboscis long and slender, more simple in structure than in the Rhagadocephala. Usually only two (lateral) longitudinal blood vessels are present.

Ocelli often numerous, variously arranged, sometimes wanting.

Lateral nerve trunks sometimes situated between the basal layer of the cutis and the external circular muscular layer; sometimes outside of the longitudinal muscular layer; and sometimes in the midst of the muscular layer of the body-wall; usually connected with a continuous nervous plexus.

In the classification adopted by Hubrecht and several other writers this group and the Rhagadocephala (or *Schizonertina*) are both raised to the same rank as the *Enopla*. To me they appear to be of subordinate value, as here indicated.

The species are all marine, and, so far as known, none of them undergo a marked metamorphosis.

Family, CEPHALOTHRICIDÆ McIntosh, Nemerteans, p. 208.

Body slender. Head elongated. Superior ganglions and commissure situated decidedly in front of inferior ones. Cephalic fossæ and pits wanting. Ocelli usually few or absent; sometimes numerous. Two longitudinal blood vessels.

Cephalothrix Œrsted, Kroyer's Tidss., iv, p. 573, 1844.

Astemma Œrsted, Kroyer's Tidss., iv, p. 574, 1844 (t. McIntosh).

Body slender, terete or nearly so. Head terete, much elongated, tapering to a point in extension. Mouth small, situated far back.

Cephalothrix linearis (Rathke) Œrsted.

Planaria linearis Jens Rathke, Skrivter af Naturhist. Selsk., vol. v, p. 84, tab. 3, fig. 11, 1799.

Planaria filiformis Johnston, Zool. Jour., vol. iv, p. 56, 1829 (t. McIntosh).

Nemertes (*Borlasia*) *rufifrons* Johnston, Mag. Zool. and Bot., vol. i, p. 538, pl. xviii, figs. 4 and 5, 1837 (t. McIntosh).

Cephalothrix linearis Œrsted, Entw. Plattw., p. 82 (note under *C. ocea*), 1844 (t. McIntosh).

Cephalothrix bioculata Œrsted, Kroyer's Nat. Tidss., vol. iv, p. 573, 1844 (t. McIntosh).

Astemma filiformis Johnston, Catalogue Brit. Mus., p. 19, 1865.

Cephalothrix filiformis McIntosh, Rept. Brit. Assoc., 1867, Trans. Sect., p. 92, 1867.

Cephalothrix linearis McIntosh, British Annelids, Part I, Nemerteans, p. 208, pl. iv, figs. 4 and 5, pl. xviii, fig. 15; pl. xxi, figs. 2, 8, 13; pl. xxiii, figs. 12 to 16, 1873.

PLATE XXXVI, FIGURES 4, 5; PLATE XXXIX, FIGURES 10 to 13, 14, 15.

Body small, nearly terete, changeable; in extension very slender, elongated, often linear or hair-like, frequently coiled in a close spiral form, usually rather thickest in the middle and tapered both ways, but often with the posterior end thicker and obtuse. Head very long and round, in full extension tapering to a slender sharp tip, in contraction often circularly wrinkled; usually, in mature specimens, without distinct ocelli; sometimes dark specks of pigment, irregularly arranged, resemble imperfect ocelli. Young examples usually

have a pair of distinct ocelli. No cephalic slits nor fossæ. Mouth small, situated far back from the snout; and usually with slightly prominent lips.

Color pale yellow, flesh-color, or cream-color, varying to pale salmon and greenish white, often with the anterior region deeper salmon or reddish, or with a median red line; sometimes the posterior part of body is bright salmon; the head and anterior portions of body often show a whitish or drab median line, due to the proboscis; lower surface paler than the upper. Proboscis very long and slender; when exerted, covered with slender acute papillæ.

Length 50 to 75^{mm}; diameter ·5 to 1^{mm}.

Long Island Sound to Nova Scotia, at many localities, between tides under stones and in sand. Noank, Conn.; Newport, R. I.; Wood's Holl, Mass.; Portland, Me.; Eastport, Me.; Halifax, N. S., etc. Also common on the northern coasts of Europe.

This species often occurs gregariously, many individuals being intricately coiled up together in a mass, often mingled with numerous pale young ones, of various sizes.

Family, Carinellidæ McIntosh.

Body elongated, roundish, decreasing backward. Head broader than body, obtuse anteriorly. Mouth small, not far back. Cephalic shallow fossæ and olfactory sacs present. Ocelli often wanting.

Carinina Hubrecht, Voy. Challenger, vol. xix, p. 5.

"Closely allied to *Carinella*, from which it differs in the presence of a distinct posterior brain lobe, situated with the rest of the brain and nerve-stems in the integument, outside of the body musculature. A ciliated canal penetrates into this posterior brain lobe."

Carinina grata Hubrecht, op. cit., pl. I, figs. 1–3; plates II, III, IV, pl. VI, figs. 1–3; pl. XI, figs. 1, 2.

This species is known only from two alcoholic specimens, which were very fully studied anatomically.

Off the East Coast of the U. S. States in 1240 and 1340 fathoms.

Order III, BDELLOMORPHA.

Body short, stout, flattened, and leech-like in appearance, with a large rounded sucker or acetabulum at the posterior end, as in the leeches. Head indistinct. No ocelli. Anterior end emarginate, with neither lateral slits nor grooves. Mouth at the bottom of the anterior emargination.

Proboscis seldom protruded in captivity, small, slender, unarmed, but with a small special bulb and sac in the middle region ; proboscis-pore close to the mouth, in the anterior notch.

Intestine not lobulated, slender, convoluted, longer than the body ; anus at the base of the sucker. Reproductive organs voluminous, filling the larger part of the body. A median dorsal and two lateral blood-vessels, with numerous branches.

Muscular walls of the body consist of an external circular, and an internal longitudinal layer. Lateral nerve-trunks are not included in the muscular layers ; they are united by a posterior commissure.

This singular group is united to the Enopla by some writers, mainly on account of the rudimentary bulb and sac in the proboscis, which certainly indicate some relationship. The simple, convoluted intestine and other peculiar features appear to me of ordinal value.

Family, MALACOBDELLIDÆ Semper.

Characters not distinguishable from those of the sub-order.

Malacobdella Blainville.

Dict. Sci. Nat., vol. xlvi, p. 270 ; Blanchard, Ann. des sci. nat., ser. 3, vol. iv, p. 364, 1845 ; op. cit., viii, p. 142, 1847 ; op. cit., vol. xii, pp. 267–276, pl. 5, 1849, anatomy. *Phylline* Oken, 1815, (*non* Abilg, 1790).

This is the only genus of the order known. Therefore the generic characters are not distinguishable from those of the order.

Malacobdella obesa Verrill.

Report on Invert. of Vineyard Sound, etc., pp. 458 [164] and 625 [331], pl. XVIII, fig. 90, 1873.

WOOD-CUT, NO. 9.

Body stout, broad, thick, convex above, flat below, broadest near the posterior end, narrowing somewhat anteriorly ; the front end is broadly rounded, with a median vertical slit, in which the mouth is situated. Acetabulum large, rounded, about as broad as the body. Intestine convoluted posteriorly, visible through the integument.

Between the intestine and lateral margins, especially posteriorly, the skin is covered with small stellate spots, looking like openings, around which are large numbers of small round reproductive vesicles. Color yellowish white. Length, 30 to 40^{mm}; breadth, 12 to 15^{mm}.

Whole coast of New England; abundant in Massachusetts Bay.

Parasitic in the branchial cavity of the long clam (*Mya arenaria*).

This species is closely related to *M. grossa* of Europe, and may prove to be identical with it. The latter occurs mostly in *Mya truncata* and *Cyprina Islandica.*

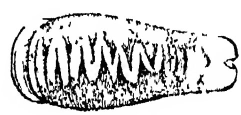

Fig. 9 *Malacobdella obesa* dorsal view, nat size

Malacobdella mercenaria Verrill

Malacobdella grossa Leidy, Proc Acad Nat Sciences Philad., vol. v, p 209 (*non* Blainville)

Malacobdella mercenaria Verrill, Report on Invert of Vineyard Sound etc, pp 458 [164] and 625 [331]. 1873

PLATE XXXIX, FIGURE 20.

Body, in extension, elongated, oblong, with nearly parallel sides, or tapering slightly anteriorly; anterior end broad, obtusely rounded, emarginate in the center, but not deeply fissured. In contraction the body is broader posteriorly. Dorsal surface a little convex; lower side flat. Acetabulum round, rather small, about half the diameter of the body in the contracted state, but nearly as broad when the body is fully extended. The intestine shows through the integument distinctly; it is slender, and makes about seven turns or folds. Color pale yellow, with minute white specks beneath and on the upper surface anteriorly, giving it a hoary appearance; middle of the dorsal surface irregularly marked with flake-white; laterally reticulated with fine white lines.

Length in extension, 25^{mm}; breadth, 4^{mm}; in partial contraction, 18^{mm} long; 5 to 6^{mm} wide.

New Haven, parasitic in the branchial cavity of the round clam (*Venus mercenaria*), October, 1871. Philadelphia, in the same species of clam (Leidy)

ADDENDA TO THE ENOPLA.

I take this opportunity to describe two very remarkable new forms of pelagic nemerteans, of which several specimens were taken by the U. S. Fish Commission Steamer Albatross, in the region of the Gulf Stream. Whether they occurred at the surface or near the bottom I am unable to say, but their form and structure is eminently adapted to a purely pelagic mode of life. In form they somewhat recall *Sagitta*, though they are much larger and stouter. The internal structure is, however, entirely nemertean, and not very different from that of the typical Enopla. In that group, however, they should form at least a distinct family (*Nectonemertidæ*). They also have some affinity with *Pelagonemertes*, but differ from that genus widely in form, as well as in having a distinct head and caudal fin, lateral cirriform organs in one species, etc. The latter, moreover, has long, much subdivided intestinal diverticula, which is not the case with our new genera. The resemblance in the structure of the muscular walls of the body and the nervous system is quite marked.

Several forms occur among the few specimens of *Nectonemertidæ* hitherto obtained. Some of them are entirely destitute of the lateral arms or cirri of the neck, which in others are large and long and give them a very striking appearance. But as small specimens of *Nectonemertes* occur in which the lateral cirri are of small size, it is probable that they would be entirely absent in still smaller specimens of that genus. In the second genus (*Hyalonemertes*) they are probably never developed.

Although I have prepared many microscopic sections of two specimens of *Nectonemertes* of different ages, I have not yet had sufficient opportunity to work out several important parts of their anatomy,—especially the structure of the brain and certain special organs in the head, supposed to be sensory. But since there is, at this time, no opportunity to illustrate the details of the anatomy, I propose to describe here only the more prominent features, reserving details for another occasion.

Family, NECTONEMERTIDÆ Verrill.

Body with highly muscular striated walls, adapted for swimming actively, elongated, more or less flattened, and with a differentiated, muscular caudal fin; the dorsal and ventral surfaces are similar.

Proboscis with a distinct bulb and sac. Mouth far forward, close to the proboscis-pore. Intestine straight, with large lateral pouches,

which are often bilobed; anus at the posterior end of the caudal fin. Lateral nerves large, not included in the muscular walls of the body, united posteriorly. A median dorsal, and two lateral blood-vessels are well developed.

Muscular walls of the body are composed mainly of a thin, outer, circular layer and a thicker inner, longitudinal muscular layer, in which the fibers are arranged in distinct bundles, except in the thinner marginal regions. A pair of long, muscular, cirriform appendages is developed from the sides of the nuchal region in one genus.

Nectonemertes, gen nov

Body decidedly flattened and with thin borders along the sides; caudal fin usually broadest at the end and sometimes bilobed. Head separated from the body by a more or less distinct neck-like portion. Lateral cirriform appendages project from the neck or posterior part of the head, in the adult. Mouth near the front of the head, just below the terminal proboscis-pore.

Proboscis long, slender, with a small bulb and sac; its sheath extends nearly to the posterior end of body. Lateral lobes of the intestine exist nearly to the end of the intestine, even into the caudal fin.

Special sense organs,* imbedded in the integument of the lower side of the head, form a cluster on each side, their ends projecting as small papillæ. Eyes of the ordinary type are, apparently, wanting. Probably the species are transparent in life and swim actively, like *Sagitta*.

Nectonemertes mirabilis Verrill, sp nov

PLATE XXXVIII, FIGURE 1

Description of the adult: Size large, up to 2 inches or more in length. Body rather elongated, decidedly flattened and with abruptly thinner marginal regions, smooth, with the walls somewhat translucent, longitudinally and transversely striated, elastic; in the middle region of the body the sides are nearly parallel; posteriorly it narrows rather rapidly to the base of the tail, and at this place, in some examples, the thin margin of the body forms a sort of fin or thin rounded lobe on each side.

* The precise nature of these organs has not been ascertained, but they are probably special sense organs.

The tail gradually thins out to the end and at the same time increases in width by the development of the thin marginal regions, thus forming a true caudal fin, in form somewhat like that of a fish. Its posterior margin is emarginate in the largest specimens, with a distinct notch in the middle, where the anus is situated, but in other specimens it is truncate. The integument of the tail shows strong longitudinal muscular fibers toward its base, while the edges are thin and delicate.

The head is ovate in form, narrowest, but obtuse, in front, considerably flattened, and usually separated from the body by a distinctly narrower neck. From the back part of the head, or commencement of the neck, a long, tapering cirrus arises on each side. The cirri have a thick, roundish, muscular base from which they taper gradually to the long, slender, lash-like, often coiled tip. These organs seem to be mere extensions of the muscular walls of the body and are not hollow.

On the ventral surface of the head and occupying a large ovate patch on each side, there is a group of small acute papillæ, projecting slightly above the surface; they are arranged in three or four irregular rows, and are connected beneath the integument with pyriform organs which can be seen by transmitted light as opaque yellowish bodies.

The proboscis-sheath is well developed and extends back nearly to the base of the tail, where it is abruptly narrowed to a short muscular band that joins the wall of the body. The proboscis is long and slender, with a small rounded muscular bulb* and a small saccular organ, much as in ordinary Enopla, though relatively smaller. When the proboscis is partially protruded. as is the case in one example, it is somewhat clavate distally and is covered with small papillæ. In transverse sections its structure is similar to that of the typical Enopla; its internal glandular layer is thick.

The intestine is large and straight; its lateral pouches are large, not much elongated, mostly bilobed distally, those in the tail becoming small and simple. The generative organs, in the form of rather large, round or ovate vesicles, occupy the lateral and ventral regions of the body-cavity, between and beyond the intestinal pouches.

In transverse sections the walls of the body are rather thin; the outer layer of circular muscular fibers is thinner than the inner

* I have been unable to find any armature in the only specimen hitherto prepared for this purpose, but the stylets, if they existed, may have been destroyed by the acidity of the alcohol in which it was preserved

layer, which is made up of longitudinal fibers arranged in bundles, so that its inner surface, in the sections, is strongly crenulated, or deeply furrowed; from the indentations between these bundles numerous strong vertical bands of muscular fibers extend from the dorsal to the ventral body-walls, between the internal organs. Toward the margins the muscular layers thin out rather abruptly, leaving the marginal portions thin and without longitudinal bundles. The general structure of the interior of the body-cavity is loose, with many spaces in the porous parenchyma, which is feebly developed, as compared with that of other nemerteans.

The lateral nerve-trunks are very large and quite interior to the muscular layers. They are situated ventrally, some distance from the edges, and near the commencement of the thin-walled marginal portion of the body. In transverse sections they are elliptical or rounded, with an excentric translucent fibrous core along the dorsal side, thus giving the cellular portion a thick-lunate or reniform shape. The lateral nerves are large and conspicuous even back to the caudal fin, where those of opposite sides unite.

The median dorsal blood-vessel and the two lateral blood-vessels are well developed and situated nearly as in typical Enopla. The lateral blood-vessels are subventral and only a short distance interior to the nerve-trunks.

There are no memoranda as to the color of the living specimens. All had been placed in alcohol when first seen by me. One that had been in alcohol only a short time was distinctly salmon, or pale orange, in tint; the others had lost all color, if they had any when living. They may have been white or colorless, and were doubtless translucent, like many other pelagic creatures. Even in alcohol some of them show considerable translucency,—nearly as much as the larger species of *Sagitta*.

The largest specimens, when first examined by me, were about 2·5 inches long and ·50 wide; subsequently they have contracted considerably by long preservation in strong alcohol.

The largest specimen now measures as follows: length 38^{mm}; breadth of body 9^{mm}; vertical diameter of body 2^{mm}; length of cirri 14^{mm}; length of head 4^{mm}; breadth of head 6^{mm}; breadth of caudal fin 4^{mm}.

Descriptions of immature specimens: A specimen from station 2076 is smaller and more slender than those described above. It has a narrower head and shows scarcely any constriction at the neck. The caudal fin is somewhat elliptical, being widest in the middle and

truncate at the end. Otherwise it agrees very well with the larger specimens. The cirri are, however, relatively shorter, their length being scarcely more than the breadth of the body, but they taper to slender tips, as do those of the adults. They are directed backward.

This specimen is somewhat translucent in alcohol and the thin, marginal bands are very distinct along the sides of the body and in the tail fin. The intestinal pouches, proboscis-sheath, and other internal organs show more or less distinctly, especially posteriorly. In the head there are about 20 sense organs (?) in each lateral cluster.

Length 35^{mm}; breadth of body 5^{mm}; length of head to base of cirri 4^{mm}; its breadth 4^{mm}; length of cirri 5^{mm}.

Perhaps this may be a male and the larger and flatter specimens females.

A specimen from station 2229 agrees in most respects with the fullgrown ones described above, except that it is smaller and has short nuchal cirri. In this the body is relatively narrower and less flattened than in the larger examples, but the head, caudal fin, and proboscis are nearly as described and figured. The nuchal cirri are, however, short, tapered, blunt, not much longer than half the breadth of the head, and stand out rather rigidly from the sides of the neck, and nearly at right angles with it.

This specimen is about 30^{mm} long; 7^{mm} broad; caudal fin 3·5^{mm} broad; length of cirri 2^{mm}. It has been treated with hardening reagents for sections, and is therefore strongly contracted

A single specimen was taken at each of the following stations by the steamer Albatross:

Station 2036, N. lat. 38° 52′ 40″, W. long. 69° 24′ 40″, 1735 fathoms. Adult.

Station 2076, N. lat. 41° 13′ 00″, W. long. 66° 00′ 50″, 906 fathoms. Young with small cirri.

Station 2229, N. lat. 37° 38′ 40″, W. long. 73° 16′ 30′, 1423 fathoms. Young with small cirri.

Station 2236, N. lat. 39° 11′ 00″, W. long. 72° 08′ 30″, 636 fathoms. Adult.

The specimen from Station 2236 is marked as having been taken in the trawl-wings. Many of the specimens of other groups, thus taken, undoubtedly came from near the bottom, but on the other hand, it is easy for any surface species to be taken in the same nets while the trawl is being lowered or when it is being taken in. Con-

cerning the other specimens there are no memoranda, but from their good condition it is more probable that they were all taken in the trawl-wings than in the trawl itself.

Hyalonemertes, gen. nov

Body elongated, fusiform, somewhat flattened, having no evident constriction at the neck, nor marked marginal folds, except in the caudal fin. Cirri wanting. Head not differentiated from the neck. Caudal fin well developed.

Proboscis long and slender, with a distinct bulb and sac, and, apparently, having a small central stylet. Lateral pouches of the intestine numerous, short, not much divided. Walls of the body thicker and more gelatinous than in *Nectonemertes*, not showing transverse striations, but covered with fine granulations; inner muscular layer longitudinally striated.

Pyriform bodies not present in the head. Eyes apparently wanting. Neither ciliated grooves nor pits were noticed on the head.

Hyalonemertes Atlantica, sp. nov

Body of the larger specimen moderately flattened, fusiform, about four times longer than broad, gradually tapered both ways; head blunt, flattened; caudal fin short, stout at base, a little broader toward the end, which is thin and slightly emarginate. Along the sides of the body the marginal fold is very narrow and indistinct, the edges being rounded; the folds become more evident posteriorly and form the borders of the caudal fin.

The integument appears somewhat soft and gelatinous, and is more translucent than in *Nectonemertes*, and not so firm. The whole surface is covered with minute soft granules hardly visible to the naked eye, but appearing, when magnified, something like fine shagreen; beneath the surface the longitudinal muscular striations can be seen. The granulation of the surface is finer and less distinct on the head. The proboscis is not protuded in this specimen. The small mouth is just below the end of the snout; near the upper margin there is a small round papilla.

Length of the larger specimen, from Station 2724, 38^{mm}; breadth of body 11^{mm}; breadth of caudal fin 6^{mm}.

Length of the smaller specimen, from Station 2428, 20^{mm}; breadth $3 \cdot 5^{mm}$.

The smaller specimen, just mentioned, is rather more slender than the larger one; its caudal fin is distinctly bilobed, with the lobes

well rounded at the end. The long slender proboscis is partially protruded, so as to show the bulb and sac in the exserted part, but not at the end; there appears to be a small stylet, but the mounted specimen is not sufficiently transparent to show its form; the exterior of the exsert proboscis is finely papillose. The large proboscis-sac extends back to about the posterior fourth; it is abruptly narrowed near the posterior end, and a band of muscular fibers near the end, on each side, binds it to the body wall. A single specimen was taken by the Albatross at each of the following stations:

Station 2428, N. lat. 42° 48', W. long. 50° 55' 30", in 826 fathoms. Young.

Station 2724, N. lat. 36° 47', W. long. 73° 25' 00", in 1641 fathoms. Adult.

EXPLANATION OF PLATES.

Plate XXXIII.

Figure 1.—*Amphiporus angulatus* Dorsal view with the proboscis partially protruded, natural size; 1*a*, the same, ventral view of the head and anterior part of the body. Eastport, Me., low-water, Aug 7, 1872

Figure 2.—The same. Dorsal view of a specimen of the reddish brown variety, more enlarged. Massachusetts Bay

Figure 3.—*Amphiporus multisorus*, sp. nov. Dorsal view of the head and anterior portion of the body, × 2 Eastport, Me

Figure 4.—*Amphiporus virescens* V. Dorsal view, × 3 Noank, Conn., July 24, 1874; 4*a*, the same specimen, posterior end, more enlarged; 4*b*, the same, ventral view of the head, more enlarged, 4*c*, the same, dorsal view, more enlarged; 4*d*, the same, head with the slightly protruded proboscis; × 8; 4*e*, the same, nearly profile view of the head, × 8 Wood's Holl, Mass., July 13, 1875.

Figure 5—*Amphiporus ochraceus* V Dorsal view; × 4; 5*a*, the same, central stylet of the proboscis, much enlarged. Wood's Holl.

Figure 6.—The same. Head and anterior portion of another specimen more contracted; × 6. Eel Pond, Wood's Holl, July 19, 1875

Figure 7.—*Amphiporus cruentatus* V Dorsal view, × 3. Noank, Conn., July 14, 1874 (No. 740).

Figure 8.—The same. Dorsal view of a larger specimen; × 6; 8*a*, head of the same specimen, more enlarged. Wood's Holl.

Figure 9.—*Tetrastemma candidum.* Dorsal view of a greenish specimen; × 6.

Figure 10—The same. Dorsal view of a specimen of the yellow variety; somewhat compressed under the microscope, × 3, low-water: 10*a*, the same specimen, showing variation in the form of the head owing to the different degree of extension. Casco Bay, low-water, 1873.

Figure 11.—*Tetrastemma vermiculus*, var. Dorsal view; × 7; 11*a*, 11*b*, other views of the head of the same specimen in different states of contraction; 11*c*, proboscis-armature of the same, much enlarged. Wood's Holl, on piles of wharf, July 24, 1875.

Figures 1, 2, and 10 are by J. H. Emerton; figures 3, 4*a* to 4*e*, and 11 to 11*c*, are by the author; the rest are by J. H. Blake. All are from living specimens.

PLATE XXXIV.

Figure 1.—*Amphiporus frontalis*, sp. nov. Dorsal view; × 2; 1*a*, the same specimen, ventral view of the head. (No. 10) Eastport, Me., 86 fath., 1870, 1*b*, the same, dorsal view of the head of another specimen. This was pale salmon with pale purplish spots on the sides due to the ovaries; proboscis-sheath greenish. (No. 86) Eastport, Me., low-water.

Figure 2.—*Amphiporus caecus*, sp nov. Dorsal view, × 5; 2*a*, 2*b*, dorsal and ventral views of the head of another specimen (No. 721); 2*c*, extruded proboscis of the same specimen, enlarged

Figure 3.—*Amphiporus bioculatus*. Dorsal view; × 5. Off Fisher's I., Conn, July 22, 1874. The ocelli are too much obscured by the color in printing.

Figure 4.—The same. Dorsal view of a younger specimen of the light colored variety, compressed under the microscope; × 10 Newport, R I.

Figure 5.—*Amphiporus roseus*. Dorsal view; × 2; 5*a*, the same, head and anterior portion of body, dorsal view, × 4; 5*b*, the same, side view; × 4.

Figure 6.—*Amphiporus tetrasorus*, sp. nov Dorsal view, × 3. Massachusetts Bay, 1878.

Figure 7.—*Amphiporus heterosorus*, sp nov. Head and anterior portion of body, dorsal view; × 1½. Massachusetts Bay, 1878.

Figure 8.—*Amphiporus frontalis*, sp. nov. Dorsal view of a small specimen partly contracted; × 3. Off Witch Rock, Massachusetts Bay, September, 1877.

Figure 9.—*Amphiporus mesosorus*, sp. nov Head and anterior portion of body, dorsal view; × 3. Massachusetts Bay, off Salem, August 13, 1877.

Figure 10—*Tetrastemma elegans* V Type specimen from life Dorsal view; × 6.

Figure 11.—*Tetrastemma vermiculus*. Young, dorsal view; × 12.

Figure 12.—*Tetrastemma vermiculus*, var. *catenula*. Dorsal view; × 8. Noank, Conn

Figure 13.—*Tetrastemma dorsale*. Dorsal view of head and anterior portion of body with protruded proboscis; × 8 Casco Bay, 1873.

Figure 14.—*Tetrastemma dorsale*, var. *marmoratum* Dorsal view; × 3. The lighter and darker mottlings are not sufficiently distinct Casco Bay.

Figure 15.—*Amphiporus bioculatus* (?). Very young, dorsal view; × 12; compressed under the microscope, while alive. Newport, R. I., September 1, 1880, station 851, 12½ fath. Color translucent white; eyes black.

Figure 16.—*Amphiporus* (*Nareda*) *superba* Copy of the original figure.

Figure 17.—*Amphiporus heterosorus*, sp. nov Head and anterior part of body, dorsal view; × 2.

Figures 2, 3, 10, 11 are by J. H. Blake; figures 4, 8, 13, 15 are by J. H. Emerton; the rest, except 16, are by the author. All are from living specimens.

PLATE XXXV.

Figure 1.—*Cerebratulus lacteus*. Young, natural size; 1*a*, the same, ventral view of head and extruded proboscis, natural size. New Haven, Conn.

Figure 2.—*Emplectonema giganteum* V. Dorsal view of a specimen not full grown; ½ natural size.

Figure 3.—*Amphiporus cruentatus* V. Dorsal view; × 4.

Figure 4.—*Amphiporus agilis* V. Dorsal view; × 4.

Figure 5.—*Amphiporus glutinosus* V. Dorsal view; × 2.

Figure 6.—*Tetrastemma vittatum* V. Dorsal view; × 8; compressed under the microscope, while living.

Figure 7.—The same. Dorsal view of the variety with a single pale dorsal stripe; × 3.

Figure 8.—*Tetrastemma vermiculus.* Dorsal view; × 8. Wood's Holl, Mass., low-water.

Figure 9.—*Tetrastemma candidum* (?). Dorsal view of a very young specimen, much enlarged; compressed under the microscope, while living. Newport, R. I, sta. 851, 12½ fath., September 1, 1880.

Figure 10.—The same. Dorsal view of a somewhat older specimen. Savin Rock, Conn., October 18, 1887.

Figure 11.—*Tetrastemma vermiculus*, var. *catenula*; × 2.

Figures 1, 6, 8 are by J. H. Emerton; figures 3, 11, are by J. H. Blake; the rest are by the author. All are from living specimens.

Plate XXXVI.

Figure 1.—*Micrura affinis.* Dorsal view, × 4. Off Martha's Vineyard, 1887.

Figure 2.—*Cerebratulus lacteus.* General view of a living specimen of the pinkish variety, natural size. Wood's Holl, July 17, 1875.

Figure 3.—*Cerebratulus luridus* V. Natural size. Noank, Conn., Aug. 8, 1874.

Figure 4.—*Cephalothrix linearis.* General view, × 8.

Figure 5.—The same. Dorsal view of the head and anterior portion of the body of a young specimen, much enlarged. Wood's Holl, Mass., August 19, 1881.

Figure 6.—*Dinophilus simplex*, sp. nov. Dorsal view much enlarged; 6*a*, the same, ventral view of head and mouth, much enlarged. Newport, R. I.

Figures 1, 2, 3 are by J. H. Blake; 4, 5, 6 are by J. H. Emerton. All are from living specimens.

Plate XXXVII.

Figure 1.—*Cerebratulus lacteus.* Pale variety, ½ natural size; 1*a*, the same, side view of head, in extension; 1*b*, the same, ventral view of head in partial contraction.

Figure 2.—*Cerebratulus fuscus.* Dorsal view of head and anterior part of body in moderate extension; 2*a*, the same specimen in a state of contraction; 2*b*, 2*c*, ventral views of the same specimen in different degrees of extension. All natural size.

Figure 3.—*Cerebratulus luridus.* Natural size, but considerably contracted in length.

Figure 4.—*Lineus dubius.* Ventral view; × 2; 4*a*, dorsal view of the head, more enlarged. August 18, 1878.

Figure 5.—*Lineus viridis.* Green variety, natural size; 5*a*, the same, side view of head, natural size; 5*b*, the same, ventral view of head, more enlarged. Eastport, Me., low-water.

Figure 6.—*Micrura affinis.* Enlarged 1½, from Eastport, Me.; 6*a*, the same, posterior end of another specimen.

Figure 7.—*Micrura inornata* V. Dorsal view; × 2. Massachusetts Bay, sta. 135, 25 fath., 1878.

Figure 8.—*Lineus socialis.* General view of the light green variety; × 2; 8*a*, the same, side view of head and anterior part of body, more enlarged.

Figure 9.—*Lineus pallidus.* Dorsal view; × 2; 9*a*, the same, side view of head; more enlarged. Massachusetts Bay.

Figures 3, 5, 6, 9 are by J. H. Emerton; 1 and 8 by A. H. Verrill; the rest are by the author. All are from living specimens.

Plate XXXVIII.

Figure 1.—*Nectonemertes mirabilis*, sp. nov. Dorsal view with proboscis partially extended; × 2. Atlantic Ocean, sta. 2036, 1883.

Figure 2.—*Cerebratulus Leidyi* V. Natural size; 2*a*, the same, ventral view of head. New Haven, Conn.

Figure 3.—*Micrura rubra*, sp. nov Peculiar specimen, probably repairing mutilation of tail. Side view; × 1½; 3*a*, the same, ventral view of head

Figure 4.—*Micrura dorsalis*, sp. nov. Dorsal view; × 1½; 4*a*, the same, ventral view of head, more enlarged. Type specimen. Eastport, Me.

Figure 5.—*Lineus arenicola* V. Dorsal view of the original specimen; × 1½; 5*a*, the same, ventral view of head.

Figure 6.—*Lineus viridis*. Red variety, dorsal view; × 1½; 6*a*, the same, side view of head; 6*b*, the same, dorsal view of a very young specimen having but four eyes; 6*c*, the same, a cluster of eggs, ⅘ natural size; 6*d*, the same, a young specimen just hatched, much enlarged.

Figure 7.—*Lineus socialis* Young, ventral view, natural size, 7*a*, the same, dorsal view of the head and anterior part of the body, enlarged. August 12, 1880

Figure 8.—*Lineus bicolor*. Dorsal view; × 5; 8*a*, 8*b*, the same, side and ventral views of head, more enlarged Wood's Holl, Mass., July 14, 1875

Figures 9, 9*a*.—*Micrura rubra*, sp. nov. Front and side views of the head; × 3 Eastport, Me.

Figures 10 and 10*a*.—*Lineus sanguineus*. Dorsal and ventral views of the head and anterior part of the body; × 3

Figure 11.—*Lineus*, sp. (?) Young, dorsal view, much enlarged, 11*a*, another view of the front part of the same specimen Vineyard Sound, among compound ascidians, 1881.

Figures 12, 12*a*.—*Emplectonema giganteum* V. Dorsal and ventral views of the head of the original type-specimen; × 2.

Figures 1, 6, 7, 11 are by J. H Emerton; 8 to 8*b* are by J. H. Blake, 2 by A. H. Verrill; the rest are by the author. All are from living specimens.

PLATE XXXIX

Figures 1, 2, 3, 4 —*Pilidium*, sp undetermined Different views; × 30. Wood's Holl, Mass, at surface, in day time, August 18, 1881. J. H. Emerton, from nature.

Figure 5.—The same; × 75; *a*, apical cirrus; *b*, apical plate; *b'*, nerve; *w*, head of developing nemertean with two eyes J. H. Emerton, from nature

Figure 6 —*Pilidium*, undetermined, sp with golden yellow spots around the margins; taken with the preceding; *a*, cluster of apical cirri; *b*, apical plate; *b'*, nerve, *c*, *c'*, anterior and posterior lobes; *d*, *d'*, lateral lobes; *e*, œsophagus *h*, *i*, developing nemertean; × 75. J. H. Emerton, from nature.

Figure 7.—*Amphiporus lactifloreus*. End of protruded proboscis, much enlarged; *s*, central stylet; *s'*, lateral stylets; *p*, posterior region of proboscis; *d*, bulbous region; *t*, saccular organ; 7*a*, one of the lateral stylet-sacs, more enlarged. After McIntosh.

Figure 8.—*Amphiporus ochraceus* V. Extruded proboscis, enlarged; *a*, anterior region; *s*, middle region with central and lateral stylets; *p*, posterior region. Camera-lucida drawing by the author.

Figure 9.—*Amphiporus bioculatus* (?). Middle portion of the proboscis, compressed under the microscope and much enlarged; *p*, commencement of the posterior region; *r*, muscular bulb; *s*, central stylet; *t*, one of the lateral stylet-sacs Camera-lucida drawing by the author.

Figures 10, 11, 12.—*Cephalothrix linearis.* Different stages in the development of the larva, much enlarged; *c*, large cephalic cilia; *a*, region of the mouth; *b*, intestinal area. After McIntosh.

Figure 13.—The same, farther developed. *o*, ocelli; *h*, ganglions; *a*, mouth area; *d*, opening of cephalic ducts; *m*, one of the cephalic sacs; *i*, œsophagus; *p*, proboscis; *b*, intestine, imperfectly developed. After McIntosh.

Figure 14.—*Cephalothrix linearis.* Head, much enlarged, and seen as a transparent object; *m*, mouth; *p*, proboscis; *p'*, rhynchodeum; *v*, proboscis-sheath; *b*, lateral blood vessel; *g*, superior; *g'*, inferior ganglion; *n*, origin of lateral nerve. After McIntosh.

Figure 15.—The same. Part of a transverse section of the body-wall adjacent to one of the lateral nerves; *c*, external cuticle layer; *c'*, basement layer; *t*, outer, and *t'*, inner circular muscular layers; *l*, longitudinal muscular layer; *n*, lateral nerve. After Hubrecht.

Figure 16.—*Carinina grata* H. Section of a part of the body-wall corresponding to that in the preceding figure with the same lettering. After Hubrecht.

Figure 17.—*Cerebratulus medullatus* Hubr. Section of the body-wall in the region of the median dorsal line, lettering the same as in the two preceding figures, with the following additional ones; *nd*, median dorsal nerve; *n*, nervous plexus; *n''*, proboscis-nerve; *l'*, inner longitudinal muscular layer. After Hubrecht.

Figure 18.—*Lineus viridis.* Transverse section through the middle of the body, × 14. *p*, proboscis; *v*, proboscis sheath; *b*, dorsal blood vessel; *b'*, one of the lateral blood vessels; *i*, cavity of intestine; *c*, external cuticular layer; *c'*, basement layer of cuticle; *l*, outer and *l'* inner longitudinal muscular layers; *t*, circular muscular layer; *t'*, transverse muscular bundles arising from *t*; *n*, nervous plexus; *n'*, lateral nerve; *ro*, reproductive organs. After McIntosh.

Figure 19.—*Cerebratulus lacteus.* Transverse section of the middle region of the body. × 8. Lettering the same as in figure 18. From nature by the author.

Figure 20.—The same. Transverse section in the region of the œsophagus, × 8. Lettering the same as in figures 18 and 19, with the following additional; *i'*, plicated wall of the œsophagus; *n''*, median dorsal nerve; *u*, *u*, nephridia. From nature, by the author.

Figure 21.—The same. Portion of the same section shown in figure 20, from the region of the lateral nerve, × 30. Letters the same as in figures 18 and 20. From nature, by the author.

Figure 22.—*Lineus viridis.* Head and anterior part of body viewed as a transparent object; *o*, ocelli; *f*, *f*, lateral cephalic slits; *g*, superior ganglion; *d*, interior of olfactory sac; *d'*, its duct; *n'*, lateral nerve; *m*, mouth; *e*, œsophagus; *p*, proboscis; *p*, rhynchodeum; *v*, proboscis sheath; *r*, *r*, blood lacunæ surrounding the œsophagus. After McIntosh.

Figure 23.—*Malacobdella mercenariæ.* Dorsal view, × 4. Newport, R. I., July, 1880, in *Venus mercenaria.* J. H. Emerton from life.

Figure 24.—*Tetrastemma dorsale.* Central stylet, × 200; 24*a*, one of the lateral stylets, × 350. After McIntosh.

Figure 25.—*Tetrastemma candidum.* Central stylet, × 150. After McIntosh.

ERRATUM

Page 384, line 23, for *Nemertinea*, read *Nemertina*.
Page 405, line 31, for *candida*, read *candidum*.

XXIII.—DINOPHILIDÆ OF NEW ENGLAND. BY A. E. VERRILL.

No representatives of this group have hitherto been described from this coast, so far as I am aware. Two species have been known to me for several years, but I have delayed publishing descriptions of them, hoping to be able to obtain additional specimens in order to make the figures and descriptions more complete. But since this group is supposed by many writers to be related to the Nemerteans, it seems to me desirable that our species should be put on record in this connection.

Both our species may be referred, provisionally, to *Dinophilus*, though they differ considerably in structure. One of them (*D. simplex*) may not be a true *Dinophilus*.

Family, DINOPHILIDÆ Graff.

Dinophilus pygmæus, sp. nov

WOOD-CUT 10

Body very small, translucent, in extension long-ovate or nearly cylindrical, capable of contracting into a short-ovate or subglobular form, composed of five segments, exclusive of the head and tail; the posterior segments are usually the largest. Each segment is surrounded near its middle by a circle of rather long and strong cilia. The head is usually rounded in tront, often nearly semicircular, and has a tuft or fringe of strong cilia around its front margin, and two transverse lateral tufts which are parts of two continuous preoral bands, one before and one behind the eyes. The eyes are rather wide apart, small, reniform, conspicuous.

The mouth is small and appears to be bilobed. The pharynx or œsophagus is short and swollen. On each side of the pharynx there is a small pharyngeal gland. The stomach is large, oblong-cylindrical, and occupies about three body-segments in ordinary extension, the intestine is narrow and terminates in an anal opening at the

Fig. 10.—*Dinophilus pygmæus*, dorsal view, somewhat compressed; *a*, mouth; *e*, pharynx and pharyngeal glands; *s*, stomach; *i*, intestine.

base of the caudal segment, which is small, short-triangular, and terminated by a tuft of large cilia. In the posterior part of the body are two relatively large, ovate, opaque, reproductive bodies, but whether they were ovaries or spermaries I did not ascertain, so that the sex of the specimen described and figured is uncertain, but it is probably a female. Color whitish. Length ·7^{mm}; breadth, as compressed, ·16^{mm}.

Taken on the piles of a wharf at Wood's Holl, Mass., Aug. 10, 1883.

This species is closely allied to *D. gyrociliatus* of Europe. The latter has, however, six post-oral segments, and differs also in the form of the head, pharynx, and stomach. How much importance should be attached to these differences is uncertain, for they may be due largely to different conditions of the specimens examined. The two may eventually prove to be identical.

Dinophilus simplex, sp nov

PLATE XXXVI, FIGURES 6, 6*a*

Body nearly smooth, distinctly segmented, in extension elongated and more or less cylindrical, the anterior part usually broadest, composed of four evident segments, exclusive of the large head and abortive tail. Segments well defined, but without any conspicuous bands of cilia. Head-segment large and long, subtriangular in front, and often pointed, but sometimes rounded. Eyes nearly lateral, small, but conspicuous. Mouth simple, elongated, situated between, or a little in front of the eyes. Stomach long and not much enlarged; intestine nearly as wide as the stomach, terminating in a nearly terminal anal pore. The tail segment appears to be rudimentary or abortive. The sex was not ascertained. Color pale yellow. Newport, R. I., Aug., 1880.

The affinities of this species are somewhat uncertain. The pharynx and stomach differ considerably from a typical Dinophilus. Reproductive organs were not observed.

XXIV.—Marine Planarians of New England.

By A. E. Verrill.

Part I.—*Dendrocœla.*

In the following paper I have brought together the scattered notes, descriptions, and sketches of our native marine planarians, made by me during more than twenty seasons spent in the study of our marine invertebrates. But as the planarians were not, at any time, a subject of special investigation with me, my observations and descriptions will be found, in some instances, incomplete and unsatisfactory. At the present time other more urgent duties prevent me from making many desirable supplementary investigations of their anatomy by means of prepared sections. Nevertheless, I trust that this article, with the accompanying figures, will prove of some value as an introduction to the study of our native species of this group, which has, hitherto, been very much neglected by American naturalists.

The unsatisfactory state of what little literature there is in existence relating to our species may be, to a great extent, the cause of this neglect. I have, therefore, endeavored to unravel the synonymy, so far as it is possible to do so with the data at hand

The drawings, except a few by myself, have all been made under my direct supervision, partly from living individuals and partly from preserved specimens rendered translucent by suitable reagents* and mounted in Canada balsam. Most of those figures (Plates 42 and 43), showing details of anatomy, and many of the general figures were drawn by my son, A. H. Verrill. Some of the general figures from life were drawn by J. H. Emerton and others by J. H. Blake for the U. S. Fish Commission.†

As a general rule alcoholic specimens of planarians cannot be identified with any degree of certainty unless rendered translucent

* In most cases the specimens have been transferred from strong alcohol to a mixture of turpentine and carbolic acid (phenol) which renders them more or less translucent, they are then mounted in balsam Various staining agents and other reagents have also been used in making these preparations

† For the use of the Fish Commission drawings in this place I am indebted to the liberality of the late Commissioner, Professor S. F Baird, this article having been in preparation before his death

by some special treatment, such as that mentioned above. When thus treated it is usually possible to identify most of the larger dendrocœlous planarians, but some of the smaller and more contractile species and most of the Rhabdocœla cannot be determined from alcoholic specimens unless studied in thin sections—a method requiring much time and giving rather uncertain results for specific identification. Such species should, therefore, be studied as fully as possible while living, and preserved by special methods on microscopic slides, so as to show their anatomy.

I have recently gone over the collections of planarians preserved in the Museum of Yale University and those contained in the collections made by the U. S. Fish Commission during many years and have identified most of the larger specimens.*

The planarians (Turbellaria) may be divided into three orders, viz:

I. Dendrocœla. In these the stomach has more or less numerous branches, often forked or arborescently divided, the body is usually rather broad and flat. Size usually large.

II. Acœla. In these there is no digestive organ distinct from the body-cavity. The mouth opens into a space lined with the body-parenchyma, and without any definite bounding membrane. The body is soft, changeable, usually flat. Size small.

III. Rhabdocœla. In these the stomach is unbranched, and usually more or less cylindrical in form, but without any anal pore. Form of body various, often thick-ovate, and even linear. As in the preceding groups, the species are nearly all hermaphrodite. The reproductive organs are very complicated and vary greatly in structure and position in the various genera and families, so that they afford very important characters for classification. The mouth occupies various positions: anterior, medial ventral, posterior ventral, etc. Size very small. Fluviatile and marine.

The Dendrocœla are divided into two suborders, viz:

I. Digonopora or Polycladidea. In these there is a central stomach from which several main branches go forth on each

* In this article all specimens recorded as collected between 1871 and 1887, unless otherwise stated, were collected by myself and others of the U. S. Fish Commission parties. The numbered stations recorded are those of the U. S. Fish Commission dredgings, made, for the most part, while I had personal charge of that part of the work of the Commission. The specimens from Eastport and the Bay of Fundy, prior to 1872, and those recorded from Long Island Sound were mostly collected by me for the museum of Yale University.

side, and also a median anterior branch; the branches subdivide arborescently and usually anastomose distally. Ovarian organs all similar; no distinct vitellaria. Male and female openings generally separate. Marine.

II. MONOGONOPORA or TRICLADIDEA. In these the central stomach is small and divides at once into three parts, viz: a median anterior, and a pair of posterior branches, from all of which simple or divided lateral branches go forth. Germaria distinct from the vitellaria. Terrestrial, fluviatile, and marine.

DIGONOPORA Stimpson, POLYCLADIDEA Lang

Digonopora Stimp., Prodromus, p 1, in Proc Acad Nat Sciences Philad., ix, p. 19, 1857

Body generally rather large, broad, flat, often foliaceous with thin undulating margins. Very changeable in form, mouth situated on the lower side, often near the center, sometimes far forward. Pharynx sometimes long, tubular; often broad, many lobed or plicated; digestive organ has a distinct, wide central portion or stomach, from which arise more or less numerous, large lateral branches which usually fork at first, or subdivide in a dendritic manner, but in most cases anastomose distally and form a reticulated network; anterior branch of the stomach situated medially, passing above the cerebral ganglion, which is bilobed.

Ocelli usually small and numerous, variously arranged, some are generally grouped over the cerebral ganglions. Tentacles sometimes present, with or without ocelli, often absent.

Reproductive organs hermaphrodite. Ovaries and testes numerous, scattered; the ovigenous and vitelligenous organs not separate. External genital openings generally two, situated behind the mouth, the female behind the male; sometimes there are two female openings, one behind the other; rarely there are several male organs, each with a separate opening. The species are all marine.

Tribe, ACOTYLEA Lang.

Acetabulum wanting. Pharynx short and wide; mouth in the middle of the body, or a little forward of, or behind the middle. Branches of the stomach ramose or reticulated. Copulatory organs situated in the posterior part of the body. Tentacles, when present, two dorsal, usually having ocelli; often wanting.

Family, PLANOCERIDÆ Lang.

Notocerideæ Diesing, Syst Helm., p 215, 1850
Planoceridæ and *Stylochidæ* Stimp, Prodromus, pp. 4, 5, in Proc. Acad. Nat Sci Philad, vol ix, pp. 22, 23, 1857

Two dorsal tentacles, usually containing ocelli. Mouth situated at or near the middle of the body. Male copulatory organ directed backward. Marginal ocelli present or absent. Cerebral ocelli generally present.

Stylochus (Ehrenberg) Lang (restr.)

Stylochus (*pars*) and *Stylochopsis* Stimpson op cit, p 22 [8], 1857
Stylochus (*pars*) Lang, op cit, p 447.

Body very changeable, usually ovate or elliptical and flat in full extension, but thicker and firmer than usual in this group when contracted. Two dorsal tentacles, each containing a conspicuous group of ocelli, and situated rather far back from the anterior end of the body. Other groups of ocelli are situated between, or in front of the tentacles over the cerebral ganglions and frontal nerves; others form submarginal rows, most numerous anteriorly. The pharnyx is furnished with several accessory plicated lobes or pouches. Male and female genital openings are situated close together near the posterior end of the body and in the typical species open into a common external pit or pore; female copulatory pouch apparently wanting in the typical species; accessory vesicle or spermatheca absent or small.

The following species are referred with some hesitation to this genus, with which they agree well in external characters. They differ from the figures and descriptions given by Lang of the European species in the structure of both male and female copulatory organs, especially in having two distinct genital openings, with the female duct opening backward. I have, accordingly, modified the generic characters so as to include them. But when their anatomy becomes better known it may be found that they belong rather with the new genus *Eustylochus*, described below. At present it seems best to put them in the older genus, which still evidently includes very diverse species.

One of these peculiar forms I have separated (see p. 466, note) as a new genus, *Heterostylochus*.

The anatomy of both the type-species of *Stylochopsis* Stimp., is still unknown. There is nothing in the original diagnosis of that group to distinguish it from *Stylochus*, as now restricted.

Stylochus zebra Verrill.

Stylochopsis zebra Verrill, Amer. Journ Sci, vol. xxiv, p 371, 1882; Annual Report U. S Com of Fish and Fisheries, for 1882, p. 666, 1884

PLATE XL, FIGURE 3, PLATE XLII, FIGURES 2, 2*a*

Size large. Body thick and firm, when active oblong or long-elliptical, usually rounded at both ends; in full extension often five or six times as long as broad, but capable of contracting to a broad oval or elliptical form. In full expansion the body is rather thin, though convex dorsally, but is nearly opaque, except at the margins, which are translucent and often more or less undulated. In strong contraction the body is convex, thick, and firm. Tentacles situated not far from the anterior end, at about the anterior eighth or tenth, and not far apart; they are short, obtuse, white, filled with very numerous, crowded, minute, black ocelli. Two large, rather open, elongated cerebral clusters, composed of numerous very minute ocelli, are situated between the tentacles and extend about the same distance forward and back of them; the hind ends of these clusters are widest and contain the greatest number of crowded ocelli; the two clusters often blend, more or less, on the median line, and terminate posteriorly rather abruptly. In some specimens these clusters are imperfectly developed, with comparatively few ocelli; in others, of large size, additional scattered ocelli occur over the whole anterior end, between the cerebral groups and the marginal rows. The marginal ocelli are minute and very numerous; around the anterior end they form three or four irregular rows, but they extend in one or two rows to the posterior end. The pharyx, as contracted, is elongated and has five or six pairs of much divided lobes anteriorly, and three or four pairs of successively smaller and simpler lobes along the sides of the elongated posterior portion, which ends not far from the middle of the body. Mouth anteriorly situated about opposite the third pair of large stomach-branches and pharyngeal lobes. There are, evidently, two genital pores, only a short distance apart and inconspicuous.* The *vas deferens* extends forward to about the posterior third of the stomach as a conspicuous

* I have already stated, on a former page, that this is not a typical species of *Stylochus*, as that genus is defined by Lang, for it differs considerably from all the European species in the structure of the copulatory organs, and especially in having two separate genital openings. But our other species seem to agree with this in that respect. It might be regarded, quite as well, as a *Planocera with marginal ocelli* and numerous tentacular ocelli.

convoluted, opaque white organ, on each side. Shell glands show through faintly as a cloudy cluster of grayish white, slender, branched, radiating tubes. The other reproductive organs show only obscurely in adult living specimens, owing to the opacity and thickness of the integument. The interior throughout most of the body is filled with great numbers of ovarian eggs.

Color, above, yellowish brown, umber-brown, or chocolate-brown, crossed by numerous yellowish or whitish lines and stripes, of which there are sometimes at least fifty, while many other similar but narrower and shorter stripes run in from the margins, between the main ones, usually narrowing and disappearing before reaching the middle of the body; toward the ends of the body the light stripes diverge more and more till those of opposite sides form v-shaped markings at each end, with a small median white stripe at the extreme end. Sometimes the light stripes become wider as they approach the middle of the back, as in the specimen figured on Plate XL, fig. 3. Some examples show an ill-defined median pale stripe posteriorly. The under side is mostly pale buff, except close to the margins, which show the alternation of brown and white stripes by translucency; the pharynx, stomach lobes, and *vas deferens* are opaque white in life, and show distinctly on the ventral side. Described from adult living examples.

Length, in life, 30 to 40^{mm}; breadth 10 to 12^{mm} or more.

Wood's Holl, Mass., on piles, and on the shore of Great Harbor at low-water, 1882; Vineyard Sound, off Menemsha, in 10 to 12 fathoms, September 6, 1886. Several fine specimens were taken on oyster beds in Long Island Sound, off New Haven, by Mr. Gilbert Van Ingen, October 29, 1892. These were all found in the canals of dead shells of *Fulgur* that were occupied by hermit crabs (*Eupagurus pollicaris*). Some of those previously taken in Vineyard Sound were living in the same situation.

Owing to the density of the pigment and the opacity of the tissues, I have not been able to make out satisfactorily the structure of the reproduction organs in this species, without sections, for which I have not yet had sufficient material in good preservation. There are, apparently, two small genital pores situated a short distance apart and relatively farther forward than in our other species of this family.

This species can always be recognized at once by its peculiar and conspicuous colors. It is, also, the largest planarian commonly found on our coast. The color is usually recognizable, even in alcoholic specimens, as well as in those mounted in balsam as translucent

objects. From our other species of the family it also differs strongly in the more anterior position of the mouth and stomach, as well as in the arrangement of the frontal and cerebral ocelli.

Stylochus frontalis Verrill, sp. nov.

PLATE XLIV, FIGURE 1

Body elliptical, large, about one inch long and half as broad. Tentacles small, obtuse, near together, well forward, nearly surrounded at the base with a ring of many ocelli, and containing very numerous, small black ocelli, arranged in two groups, one on the antero-lateral, and the other on the inner-lateral surface. Frontal, and cerebral ocelli form a large, median, double cluster containing very many small ocelli, situated before and between the bases of the tentacles and running to a point back of them, so as to form a median triangular patch, and extending forward in the form of a fan, or large open triangular group, formed by the nearly complete blending of the two lateral clusters, and becoming more widely scattered toward the anterior margin. Marginal ocelli minute, forming two or more closely crowded rows, close to the edge and most numerous on the middle part of the anterior border, but extending to the sides.

Color, above, yellowish gray, mottled with yellowish brown, and marked with the brighter orange-colored, repeatedly forked and branched intestinal branches, which show best toward the paler margins, and with unequal, rounded, scattered spots of dark brown around the central region. The pharynx and stomach cause a central whitish patch, narrowing backward; behind this there is a small pale patch, near the posterior end, caused by the reproductive organs. The under side of the body is paler than the upper.

Length, in life, about 25^{mm}; breadth 12^{mm}. Described from life.

One living specimen was taken at Provincetown, Mass., from the bottom of a whaling vessel recently returned from a cruise off the Carolina coast in 1879. Some of the associated species were of distinctly southern origin.

The reproductive organs were not well seen, owing to the dark color of the pigment. There appear to be two genital openings, near together. The mouth is in advance of the middle of the body. The pharynx has about five principal branches on each side, decreasing backwards, while the posterior end extends some distance beyond the last branches. The branches of the stomach are much divided dichotomously; but do not seem to anastomose to any great extent.

Stylochus crassus Verrill, sp nov.

Description of a specimen preserved and rendered partially translucent:—Body large, thick, rounded, nearly as broad as long. Upper surface covered with minute, whitish, conical papillæ, barely visible to the naked eye. Mouth nearly central. Stomach with about five or six main lateral branches, which have very numerous divisions and anastomose freely distally. A short distance behind the mouth there is a rather large and slightly prominent sucker-like organ or acetabulum.

Ocelli are minute and very numerous, forming two large, elongated, sub-parallel groups, broadest posteriorly and tapering anteriorly; at its posterior end each group expands into a wide, roundish, rather open cerebral cluster, which is connected by a narrow band of ocelli with another similar roundish cluster a little farther forward, over the anterior part of the brain, beyond which the groups gradually diminish in breadth to their anterior ends, not far from the front margin of the body. At about the anterior fourth, and a little back of the posterior part of the cerebral groups, and somewhat farther apart, are two low, inconspicuous prominences, which appear to be the retracted tentacles; each of these contains a small group of minute ocelli, not easily distinguishable

Marginal ocelli are minute and not very numerous, forming about two rather irregular and indistinct rows anteriorly, but the margin is somewhat abraded and some of its ocelli may have been destroyed.

Most of the interior of the body is densely filled with small ova. The density, thickness, and opacity of the tissues render the study of the reproductive organs impossible, except by sections, for which my single specimen is not suitably preserved.

Color of the preserved specimen dull brown, covered above with small white specks, due to the papillæ.

Length and breadth of the alcoholic specimen about 25^{mm}; thickness 2 to 3^{mm}.

Station 2732, U. S. Fish Com. steamer Albatross, Oct. 26, 1886, N. lat. 37° 27′; W. long. 73° 33′, in 1152 fathoms, dark green mud.

Only one specimen was taken. It is remarkable for its great size, thickness, and solidity. I refer it to this genus only provisionally, because its reproductive organs are unknown. I detected only a single genital pore, of small size, near the posterior end, but a second may exist, for the specimen is broken and not well preserved in that region. The arrangement of the ocelli is sufficient to distinguish it from all other American species.

It is possible that it lives at the surface among floating algæ, and not at the bottom.

Eustylochus, gen. nov.

Tentacles with ocelli in the sides, or base, or both. Cerebral ocelli variously arranged. Marginal ocelli present. Stomach branches numerous; distal branches anastomosed.

Male and female genital pores separate, the female ducts opening backward. Seminal vesicle well developed, usually distinctly three-lobed, the middle lobe with a long duct leading to the penis. Penis-sheath short and thick; penis styliform; granular gland not prominent, closely attached to the penis-bulb, often indistinct.

Female orifice not far back of the male organ; it connects with the vagina and with a long, narrow median duct which starts from the orifice and runs forward to or near the gastric region, where it connects with a flask-shaped vesicle, which is probably a spermatheca or seminal receptacle. The vaginal duct expands into a short, swollen glandular portion, which bends upward and backward upon itself, and receives the uterine ducts.

This genus agrees externally with *Stylochus*, but its reproductive organs are very different from those of that genus.

The only European species which is described as having a similar spermatheca and median duct is *Stylochus maculatus* Quatrefages,* but that differs in other characters.

Eustylochus ellipticus (Girard) Verrill

Planocera elliptica Girard, Proc. Boston Soc Nat. Hist., vol. iii, p. 251, 1850 (description very brief and imperfect): op. cit, p. 348 (note on its embryology). Embryonic development of *Planocera elliptica* in Journal Acad Nat. Science of Philadelphia, vol ii, p 307, sep copies, pp. 7–27, pl 1–3, 1854 (details of its embryology, but no description of adult).

Stimpson, Prodromus, in Proc Philad. Acad. Nat. Sci., vol. ix p. 25 [5], 1857.

Lang, Polycladen des Golfes von Neapel, p. 463, 1884 (copy of Girard's 1850 brief description).

Stylochopsis littoralis Verrill, Report on Mar. Invert. of Vineyard Sd, etc, pp. 325 [31], 632 [338], pl. 19, fig 99, 1873.

Stylochus littoralis Lang, Polycladen des Golfes von Neapel, p 453, 1884 (copy of description in work last cited).

PLATE XL, FIGURE 2; PLATE XLI, FIGURES 1, 1*a*; PLATE XLII, FIGURES 1, 1*a*.

Body flat with thin, often undulated, and very flexible margins; very changeable in form, usually, when creeping, long-oval, elliptical, or oblong; in extension often narrowed anteriorly, but when at rest rounded or subtruncate at the ends; often with a small median

* This species, as described and figured by Quatrefages, differs so much from all related forms, that it should, undoubtedly, constitute the type of a new genus, for which I propose the name *Heterostylochus*. Some of its characters are as follows:

posterior lobe, but at other times with a notch in the middle of the posterior margin; frequently the breadth exceeds the length, but more commonly it is less than half. The tentacles are small, round, elongated and tapered in full expansion, often obtuse in partial retraction, translucent white, each containing an elongated, crowded group, extending from the base nearly to the tips, consisting of about twelve to twenty-five small, but conspicuous, black ocelli. The tentacles are situated at about the anterior fourth of the body, and are usually separated by a distance equal to about one-fourth of its breadth, but the relative positions of the tentacles change according to the degree of extension. Frontal and cerebral ocelli usually about eight to twelve, often more in the largest specimens. They usually form four or six small paired groups; the two groups most in advance of the tentacles and situated over the frontal nerves sometimes contain three or four ocelli each, but more commonly only two; the next pair of groups, which are nearer together and situated between or a little in front of the tentacles, about over the apex of the cerebral ganglions, or near the base of the large frontal nerves, usually contain each only two or three ocelli, one of which is larger than the others, but in some adult specimens they contain four or five ocelli, the number in that case often varying in the right and left clusters; a little farther back and directly over each gangloin there are often one or two pairs of ocelli; occasionally there are others placed singly over the posterior part of the gangloins. Young examples often have only the two front pairs of groups, each consisting of two ocelli. Marginal ocelli numerous, black, easily seen with a lens; they are most numerous on the anterior margin, where they are arranged mostly in two or three or more irregular rows along the pale border; they extend back to the middle of the sides or beyond, gradually decreasing in numbers backward; a few ocelli, which are usually loosely arranged somewhat in radial rows over the

Heterotsylochus, gen. nov.

Tentacles with lateral ocelli; cerebral ocelli form two groups; apparently no marginal ocelli. Main stomach-branches few Genital openings separate. *Vasa deferentia* large, discharging into the ejaculatory duct; seminal vesicle large, rounded, sessile. Muscular penis-bulb pyriform A long, narrow, median duct (*vagina* Quatr.), runs far forward from the female orifice and expands into a flask-shaped seminal receptacle or spermatheca near the male organs; a swollen egg-duct also connects with the female orifice.

Type *H. maculatus* (Quatr. sp.) from Saint Malo, under stones. (See Ann. des sci. nat., iv, p. 144, pl. IV, figs. 3, 3*a*; pl VI, fig. 2, anatomy).

Stylochoplana maculata Lang, op. cit., p. 459.

frontal nerves, anteriorly, but often appear irregularly scattered, occur farther from the margin than the main rows.

Mouth submedian, or at about the anterior third. Pharynx, when everted, short and broad, with numerous short, flattened lobules. The retracted pharynx has about six or seven pairs of principal lateral lobes and some smaller ones anteriorly and posteriorly. The six or seven pairs of lateral branches of the stomach, and also the anterior and posterior ones, have many dendritic branches at first, but distally anastomose freely making an intricate network.

The copulatory organs lie in an elongated whitish spot, close to the posterior end. The most anterior part of this spot contains an elongated, swollen, median seminal vesicle, which tapers backward, and has two lateral lobes, continuous with the *vasa deferentia;* back of this the small, opaque white, elliptical or barrel-shaped male organ is more or less distinctly visible; the penis is short, straight, tapered, and appears to end at a small distinct external pore. The *vas deferens* extends forward, on each side, to the middle of, or sometimes nearly to the anterior end of the stomach, in the form of a much convoluted opaque white organ, often distinctly visible from beneath, through the integument, even with the naked eye.

Just back of the penis, and more indistinct, there is a smaller, swollen, short, pear-shaped female copulatory organ (vagina or copulatory pouch) which has thick, rather opaque, glandular walls; it is surrounded by, and connected with a larger translucent organ or cavity, and opens externally by the small genital pore at its posterior apex. The glandular part of the vagina, in most preserved examples, appears to be short, ovate or pear-shaped when seen from the ventral side, but its front end bends upward and then backward on itself, the dorsal bend being of nearly the same shape and size as the ventral part, is mostly concealed by it; the apex of the dorsal fold, in the largest examples, again bends forward, so that the entire organ in profile, is somewhat S-shaped, but this is not the case in some of the smaller specimens. From the external female orifice a narrow but very definite duct runs forward, in the median line beyond the penis and seminal vesicle to the gastric region, where it expands into an elongated flask-shaped vesicle, which lies below the stomach.* This appears to be a seminal receptacle or spermatheca.

* An organ precisely like this is figured by Quatrefages (op cit, pl vi, fig 2*l*), as present in his *Stylochus maculatus* (*Heterostylochus maculatus* V.), as described in note on page 466. By him it was considered a copulatory sac or seminal receptacle, and he called its duct the vagina Others have doubted whether it forms part of the

Close to the female genital orifice there is a minute pore, from which runs forward a long narrow duct (often distinctly stained with carmine in the preparations). This appears to be the main nephridial duct; it was traced as far as the gastric region.

Color pale or deep yellowish brown, greenish brown, salmon, smoky brown, greenish yellow, etc., irregularly radially veined or reticulated with a pale, translucent, yellowish, whitish, or salmon ground-color and usually with a light brown, yellow, or whitish, irregular, laterally lobed median stripe, most distinct posteriorly; a small posterior pale spot; margins pale. In some examples the yellowish brown color appears in the form of thickly arranged, irregular, angular spots and patches on a pale translucent ground, while the stomach, pharynx, and reproductive organs (*vas deferens*) cause an elongated, irregular, lobulated, whitish median patch, more distinct on the under side; beneath white, pale gray, or pale flesh-color, or salmon, with a median, elongated, lobulated, light patch, due to the stomach and *vasa deferentia.*

Length of adults 20 to 25^{mm} in extension; breadth, about 6 to 10^{mm}.

New Haven, Conn., to Casco Bay, Maine, common in shallow water and between tides, under stones, and in tide-pools.

Fort Hale, South End, and Savin Rock, near New Haven; Thimble Islands, abundant; Newport, R. I., on piles of bridges and wharves, 1880; Wood's Holl and Vineyard Sd., Mass., common; Provincetown, Mass., at low-water mark, common, Aug., 1879; Salem and Gloucester, Mass., on piles, 1877, 1878. Quahog Bay, Maine, at low-water, 1873; Banks of Newfoundland (?), T. M. Coffin. A number of large specimens were taken by Mr. Gilbert Van Ingen, Oct. 29, on the piles of the railroad bridge across West River, near New Haven, where the water is distinctly brackish. Each one was inside the shell of a recently killed barnacle (*Balanus eburneus*) and was evidently feeding upon its flesh. The barnacles may, however, have been killed by some other agency.

A specimen taken at Savin Rock, near New Haven, laid its eggs on July 12th in large clusters placed close together on the inside of a glass bottle. The eggs themselves were very small and white.

This is decidedly the most common species of the larger planarians found on the shores of New England, especially south of Massachusetts Bay. I have not obtained it during many seasons of collecting

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reproductive system In our species its connection with the orifice that I take to be the female genital pore is very obvious in some prepared specimens, in which the duct has taken a deeper stain than the surrounding parts

at Eastport, Me., nor elsewhere in the Bay of Fundy. Therefore the specimen received from Capt. Coffin marked as from the Newfoundland Banks may be regarded as doubtful, as to locality.

I have referred this species to the *Planocera elliptica* of Girard with much hesitation, for Dr. Girard did not publish any description of his species by which it could be identified. He did not even mention the arrangement of the ocelli in either of his papers, but said, incidentally, that he understood the genus *Planocera* as including *Stylochus*. Hence it may be inferred that his species had ocelli in the tentacles, but not necessarily marginal ocelli. My principal reason for uniting *S. littoralis* with his species is because it has proved, in my experience, to be the common shore species in the region of Massachusetts Bay, where Girard obtained his specimens. Nor have I found in that district any other species which could be referred to his species with any degree of probability whatever. As Dr. Girard published an important paper on the embryology of his species, it is very desirable to retain his specific name, if it can be located with any considerable degree of certainty.

Planocera Blainv, 1828 (emend)

Planocera Stimpson, Prodromus, p 5, 1857 (emend)
Lang, Polycladen, p 434, 1884 (emend)

Body oval or elliptical and rather flat in extension, thickened and convex when contracted. Tentacles slender, tapered, retractile, situated at some distance from the anterior end of the body. A cluster of ocelli is generally situated in the base of each tentacle; usually others form clusters between and behind the tentacles; marginal ocelli wanting in the typical species, sometimes numerous. Genital pores separate, but near together, situated a short distance from the posterior end of the body; female duct is short U-shaped, usually with a copulatory pouch and accessory vesicle (spermatheca); the vagina opens backward; the spermatheca is above or behind the vagina.

I have modified the generic characters so as to include species which, like the following, have marginal ocelli, but otherwise agree nearly with the typical species. For this group I propose, however, to establish a new subgenus:

Subgenus, **Planoceropsis**, nov.

Tentacles, cerebral ocelli, pharynx, and stomach as in typical *Planocera*; marginal ocelli present. Reproductive organs mostly

similar to those of typical *Planocera*, but the seminal vesicle is free and three-lobed, with the central lobe elongated, tapering backward into a narrow duct that joins the penis, while the side lobes are continuous with the *vasa deferentia* ; the penis-sheath is short, thick, conical ; the penis is short, styliform. Female duct runs forward a short distance from the opening and then bends upward and turns back on itself, forming a U-shaped tube.

Planocera nebulosa Girard

Planocera nebulosa Girard, Proceedings Philadelphia Academy Natural Sciences, for 1853, vol. vi, p. 367, 1854, Verrill, Report on Invert. of Vineyard Sd., etc., in Annual Report U. S. Com. of Fish and Fisheries for 1871, pp 325 [31], and 632 [338], pl XIX, fig. 100, 1873; Lang, Polycladen, p. 467

PLATE XL, FIGURE 4, PLATE XLII, FIGURE 3

Body convex above and rather thick, especially in contraction. In usual extension, broad-elliptical or oblong, but capable of becoming long-elliptical or nearly circular ; edges sometimes thin and undulated. Tentacles rather long, slender, tapered, translucent whitish, retractile, situated near together and well back from the front margin ; no ocelli in the distal portion, but a cluster of small ocelli is situated in the base. Mouth and stomach nearly central ; the pharynx and stomach have four or five main lobes on each side, and the mouth is a little behind the middle of the stomach ; in some states of expansion the anterior and posterior lobes are somewhat prolonged. The bilobed cerebral ganglion is situated between or a little before the bases of the tentacles. No ocelli were observed in the deep colored living specimens, above described, but when looked for in sections they are found to be numerous. The ocelli in the bases of the tentacles form small rounded clusters, more easily visible from below than from above. Just back of each tentacle and a little more toward the median line there is a larger and more open cluster of ocelli; in the cerebral region there is a pair of small inconspicuous groups, each containing about two or three ocelli, while a few others are apparently irregularly scattered between and in front of the tentacles. The marginal ocelli are also minute and form two or three rows, some of which extend back to about the middle of the sides.

Genital orifices two, small, near together, not far from the posterior margin.

Color somewhat variable. Our specimens were usually olive-green with the paler ground-color showing more or less as whitish or

yellowish lines and mottlings; median dorsal stripe pale or greenish white; margin whitish; sometimes the dark color is in the form of distinct irregular spots or blotches; ventral surface yellowish green, with the pharynx opaque whitish.

According to Girard the original specimens were dark gray, on a pale ground, and the median stripe was reddish,—a variation similar to that common in *Eustylochus ellipticus.*

Length 20^{mm}; breadth 10 to 12^{mm}, in extension.

New Haven, Conn., 1865, 1870, 1892; Newport, R. I., 1880; Wood's Holl., Mass., under stones near low water mark, 1880; Charleston, S. C. (Girard.)

On the southern New England coast this species is not common,—at least I have found it only in few instances and in small numbers during more than twenty seasons spent in collecting marine animals on these shores. Most of the specimens are immature.

The structure of the internal reproductive organs of this species, owing to its opacity and dark color, were not well made out, in the adult specimen described above. Some additional observations on a smaller and somewhat immature specimen, apparently of the same species, recently obtained living, are here given.

This specimen agrees with the larger and more characteristic ones described above in the arrangement of the ocelli, which, owing to the lighter colors of the integument, could be made out in the living specimen, though they are minute. The tentacles, however, were relatively smaller than in the larger specimen formerly described. They are tapered, acute, translucent whitish, without ocelli except in the strictly basal part, so that they can scarcely be seen from above, but seen from beneath they form a small round group; the clusters behind and between the tentacles, those in the cerebral region, and the marginal ocelli are nearly as described above, except that they are rather less numerous. They can hardly be seen with a pocket lens. Scattered, minute, marginal ocelli occur even at the posterior margin. The color is light olive green, irregularly radiated and reticulated with rather faint, greenish white lines; margins and tentacles whitish; a median streak over the stomach and a small elliptical spot close to the posterior end, and inclosing the copulatory organs, are greenish white. Lower surface pale, the pharynx, stomach, and *vas deferens* showing through as more opaque white organs. Mouth central; pharynx with about six main lobes on each side.

In this living specimen the reproductive organs (Pl. XLII, fig. 3)

could be seen indistinctly when it was compressed under the microscope. There are apparently two small genital pores, near together, but distinct, as in *E. ellipticus,* with which this species seems to agree nearly in the structure of its reproductive organs. The convoluted *vas deferens,* which runs up, on each side, to about opposite the middle of the stomach, discharges into the lateral lobes of a relatively large, three-lobed, or somewhat anchor-shaped, seminal vesicle, which is more conspicuous than most of the other organs; its three lobes point backward, while its anterior end is broadly rounded; its middle lobe is longer than the others, and connects with a narrow efferent duct. The male copulatory organ is broad-elliptical, terminating in a conical penis-sheath and a small, short, straight, tapered penis, which terminates close to a small external pore. The larger or elliptical part of the male organ may be, at least in part, a "granular gland," but I was unable to clearly distinguish between the penis-bulb and the glandular organ. The female organs consist of two evident parts; the more anterior portion is a small elliptical vesicle (copulatory pouch ?); with a posterior pore; the posterior portion is a narrower and more tubular organ, which appears to be a simple spermatheca. This specimen is not mature sexually and the female organs are not well developed.

I have referred this, with considerable doubt, to Girard's species. for the description of the latter was very meagre, and there is considerable difference in color. The color, however, is quite variable in this group. The southern form may prove to be a very distinct species.

The generic relations of this species are somewhat doubtful. In general structure, and especially in the characters of its tentacles and dorsal ocelli, it agrees well with the typical species of *Planocera,* but the latter genus is described by Lang and others as destitute of marginal ocelli, which are numerous in our species. In the structure of the reproductive organs it agrees more nearly with *Planocera* than with *Stylochus,* as described by Lang.

In many respects the reproductive organs are like those of *Eustylochus,* and it is possible that its affinities may be even greater with that genus than with *Planocera.* But as there is but a single specimen available for the study of the reproductive organs, and that seems to be immature, I am unable to determine some of the details which are desirable before its position can be fully established.

The presence or absence of marginal ocelli might be regarded as not of generic importance. In that case the present species might be defined as a *Planocera* with marginal ocelli.

Imogine Girard, 1853.

Imogine Stimpson, Prodromus, p. [4] 22, 1857; Lang, Polycladen, p. 445.

Body thin, foliaceous. Tentacles with a single rather large ocellus at the tip. Anterior border furnished with marginal ocelli. Reproductive organs unknown.

Imogine oculifera Girard

Imogine oculifera Girard, Proc Philad. Acad. Nat Sci., p. 367, 1853; Stimpson, Prodromus, p. [4] 22; Lang, op. cit., p. 446.

Plate XL, figure 1.

The only specimen that I have seen was small and immature. The reproductive organs were not developed. The body of this was very thin, obovate, with a broadly rounded anterior and a narrowed posterior end, when creeping. The tentacles were distant from the front margin, clavate, each with a very distinct ocellus in the rounded tip. The ocelli formed two linear divergent groups of about ten each, commencing between or a little behind the tentacles and extending much beyond them anteriorly. The pharynx and stomach were not well defined, but the stomach appeared to have rather numerous (at least seven or eight) main lateral branches, which were much divided distally, and appeared to branch dichotomously.

The color, to the naked eye, appears bright red with pale margins; when much enlarged the bright carmine red is seen to form irregular radiating and branched lines, corresponding to the branches of the stomach, while the narrow intervening spaces, the gastric region, the cerebral area, the tentacles, and the margins are translucent whitish. The margin is, however, covered with small pale yellow spots.

Length of the young specimen described and figured, in life, $4{\cdot}5^{mm}$; greatest breadth $1{\cdot}5^{mm}$. According to Girard, this species becomes 1·5 inches long; ·5 wide.

Buzzard's Bay, at Quisset Harbor, in 4 or 5 fathoms, on sandy bottom, Sept. 4, 1882. Charleston, S. C. (Girard).

Family, Leptoplanidæ Stimp., 1857.

Body broad, flat, usually thin or foliaceous. Tentacles none. Mouth ventral, near the center of the body. Pharynx large, lobed or plicated. The main lateral branches of the stomach vary in number; the distal branches often anastomose freely. Ocelli nu-

merous, usually forming four groups, two of which are cerebral, and two dorsal in the position of the tentacles of *Planoceridæ*. Marginal ocelli sometimes present, often wanting or indistinct. The copulatory organs are situated behind the mouth and more or less distant from the posterior end of the body. The male organ is directed backward. Male and female genital pores are usually considerably separated, but sometimes have a common external opening. In some genera a second female orifice is situated behind the ordinary one. No marked metamorphosis.

The species and genera of this family are not easy to distinguish without a careful study, both of the living and prepared specimens. The majority of the species, while living, closely resemble each other in form, color, habits, etc., although the internal organs may show great diversities in arrangement and structure. Unfortunately it is generally difficult, if not impossible, to make out much of the internal anatomy while the animals are alive, owing to the thickness, density, and imperfect translucency of the tissues; the presence of large quantities of ova; the frequently deep colors, etc. On this account the species, as collected, are frequently confounded, and the rarer species, being mistaken for common ones, are often overlooked. The only sure way, therefore, is to save all the specimens seen.

Even the arrangement of the ocelli is apt to be deceptive, for many very diverse species have the ocelli arranged in almost exactly the same way. Moreover the number of ocelli and the forms of the clusters in each species vary widely, according to the age of the individuals; and the form and relative positions of the clusters of ocelli change greatly according to the states of contraction and expansion. In life, part of the ocelli are apt to be overlooked on account of their being more or less deeply imbedded in the integument, and perhaps, also, partly concealed by pigment, as well as because of their very small size in some species. The marginal ocelli, especially, are liable to be overlooked in several species, owing to their minuteness. I have found it impossible to see the marginal ocelli with the best of simple lenses, in some of our species, while they were alive, but could see them easily when the same specimens were properly preserved and mounted.

The form is continually changing in life, and preserved specimens are apt to contract in all sorts of shapes, unless care be taken to confine them between glasses before killing.

The colors of each species, in life, are usually variable through a wide range of tints, and the special color-markings, when due to the

branches of the stomach, or to the reproductive organs, vary according to the kind and quantity of food, the season of the year, etc. Hence the forms and colors are usually of secondary importance in distinguishing the species and genera.

The form and structure of the reproductive organs are here of the greatest importance, but these organs can usually be seen only very imperfectly, if at all, unless the specimens are preserved and mounted in such a manner as to render them translucent.* A few species are sufficiently translucent while living, especially when immature, to afford a fairly good view of their internal organs when slightly compressed between glass, especially immediately after they are killed with some agent that does not coagulate the fluids of their bodies.† The structure of the pharynx and the number and modes of division of the main branches of the stomach afford characters of great value that can be easily observed.

I have good reasons for beliving that there are a number of species of this group living on our coast, that are not included in this article. This is doubtless largely due to lack of attention to this family on the part of collectors, myself included, owing partly to the prevalent impression that all the forms are members of one or two common species. I have observed young specimens of several kinds, too immature to describe specifically, that are evidently not the young of any of those here included.

Leptoplana (Ehrenberg) Lang, (restr.)

Polycelis (*pars*) Quatrf., Ann des sci. nat., ser. 3, vol. iv, p. 133, 1845; Voyage en Sicile, ii, p. 33, 35.

Leptoplana and *Elasmodes* (*pars*) Stimp., Prodromus, p 3, 1857.

Body foliaceous, usually with thin undulated margins, usually elliptical or oblong, changeable. Ocelli numerous, forming four groups: cerebral and dorsal. The anterior or cerebral ones are situated over the cerebral ganglions, the dorsal groups occupy the position of the tentacles found in *Planoceridæ*. No marginal ocelli. Pharynx with more or less numerous broad, short accessory lobes.

Genital pores rather widely separated, the male pore distant from the posterior end of the body. Female pore opens backward and is

* It must be noted that the form and relative positions of these organs are more or less altered by all modes of preservation, owing to contraction of the tissues.

† I have found hydrogen peroxid an excellent reagent for this purpose Nitric acid often does very well, as do many other agents in common use Alcohol, corrosive sublimate, chromic acid, etc, render the tissues more opaque.

often in a circular pit; the female duct is usually elongated and forms a siphon-shaped organ, the longer and narrower leg of the siphon above the vagina, and extending backward into a more or less dilated spermatheca; the middle portion of the vagina* is thickened and receives, on each side, numerous ducts from the shell-glands. In at least two of our species there appears to be a small posterior genital pore connected with the spermatheca by a narrow duct, somewhat as in *Trigonoporus.*

A large, round or pyriform, thick-walled "granular gland" is connected with the male organ. Seminal vesicle usually well developed. Penis or verge often long and cirriform. In some species a sucker exists between the genital pores.

The most obvious distinction between this and the closely allied genera is the unusual elongation of the female ducts and the verge, and the consequent wide separation of the genital pores. The absence of marginal ocelli seems to be constant.

Leptoplana virilis, sp. nov.

PLATE XLIII, FIGURES 1, 1*a*

Description of living specimens:—Body thin, more or less elliptical, changeable. Ocelli conspicuous, black, arranged in four distinct, rather large groups, those in the posterior or dorsal groups largest; the posterior groups are short-oblong or somewhat quadrangular, divergent, situated near the ganglions, and have each about twelve visible ocelli; the anterior or cerebral groups are nearly parallel, elliptical or oblong, a little nearer together than the others, and usually commence between the latter and extend considerably farther forward over the ganglions; they consist of many minute ocelli and each has a single distinct ocellus, larger than the others, at the posterior, and another at the anterior end of the group.

Color pale brown covered with darker brown specks and with poorly defined pale blotches.

Length 18^{mm}; breadth 10^{mm} in extension.

Description of a specimen mounted in balsam:—This specimen (pl. XLIII, figs. 1, 1*a*) shows that the ocelli are somewhat more numerous than described above, part of them being too deeply seated to

* The first, or thickened, glandular portion of the duct (*v*, pl. LXIII, fig 1*a*) is usually called the *vagina*, but it may not be the copulatory duct, at least in such species as have a second female orifice farther back leading to the spermatheca, as in *Trigonoporus.* The latter duct, in such cases, is probably the true copulatory duct, the other serving for the laying of the eggs.

be readily seen in life; the anterior clusters are shorter than in life, owing to contraction. The retracted pharynx has five pairs of large lateral lobes, and a pair of smaller ones anteriorly. The mouth is about opposite the second pair of large lobes.

The greater part of the body is filled with small rounded ovarian folicles (*o*, *o*) crowded between and around the branches of the stomach. A still larger number of spermaries (*t*, *t*), of smaller size, are arranged around and between the ovaries.* Only a part of them are represented in the figure.

The male organs of copulation are larger than in most species and rather conspicuous. The muscular penis-sheath (*q*) is stout-cylindrical, or slightly clavate, longer than broad. Its anterior part is covered by a nearly globular "granular gland" (*k*) with thick, dark colored walls. The seminal vesicle (*r*) in a ventral view appears like a rounded cap anterior to, and above the granular gland; it consists of a median and two lateral lobes. The penis (*p*) is long, slender, and somewhat enlarged at the end, as seen in this example, in which it is retracted and probably unnaturally crooked and twisted, owing to the mode of preservation.

The female genital pore is situated at the bottom of a large and deep funnel-shaped pit (perhaps produced by contraction), and is situated about a third of the distance from the male pore to the end of the body. The female duct (*v*, *v'*) extends forward to near the male pore where it bends upward and turns abruptly backward on itself, and then becoming a narrow tube (*v'*), runs backward considerably beyond the male genital pore and connects with a rather large and nearly round spermatheca or *receptaculum seminalis.*

This organ (*s*, *s'*) seems to consist of two parts or compartments, for in some specimens there can be seen a smaller rounded organ (*s'*) overlapping or resting upon its anterior side and apparently having its cavity continuous with the other. In other specimens it is in front of the main vesicle and seems joined to it by a neck. These parts are, however, much obscured by the glandular organs of the region, the stomach branches, and other organs. The first or ventral portion of the female duct (*v*), which is usually considered the vagina† or *bursa copulatrix* is rather thick, increasing in diameter to the anterior bend, and it receives, on each side, the ducts of very

* This preparation has been stained with borax-carmine and with picric acid, so that the organs show very plainly. The spermaries are dark brown and the ovaries bright red. Other mounted specimens of the species agree well with this one

† See note under the genus, p. 477

numerous "shell glands" (*w*) which radiate outward and backward from it. The outlines and connections of the large uterine sacs, which also join the vagina, cannot be distinctly seen, but they lie alongside the stomach, and are filled with eggs. The *vas deferens* also runs up along each side of the stomach as a convoluted tube.

Off Cape Cod, at Station 307, in 31 fathoms, 1879; also at Station 747, off Nantucket Shoals, in 13½ fathoms.

Leptoplana variabilis (Girard) Diesing

Polyscelis variabilis Girard, Proc. Boston Soc. Nat. Hist, vol. iii, p 251, 1850.

Leptoplana variabilis Diesing, Revision Turbell., Sitz mathem-nat, xliv, p. 542, 1861

PLATE XLI, FIGURE 7, PLATE XLIII, FIGURES 2, 2*a*, 3, 3*a*, 3*b*.

Description of living specimens:—Body thin, smooth, oblong or elliptical in extension, with the edges usually much undulated; very active and changeable in form.

Ocelli black and conspicuous; the cerebral clusters, which are situated over and in front of the ganglions, are decidedly elongated, usually fusiform and distinctly widest in the middle, but sometimes widest at the front end, subparallel or more or less divergent, and changeable in position according to the extension or contraction of the tissues about them; the hind end often extends as a narrow line or single row of ocelli back of the dorsal groups; the cerebral clusters may contain 25 or 30 ocelli each. The posterior or dorsal clusters are more or less circular or oval, each containing ten to fifteen rather large, conspicuous, black ocelli; a few of those in front are usually larger than the rest.

Color often yellowish brown, becoming paler toward the translucent margins and darker around the light gastric streak. The ganglions and nerves are not red.

Other specimens (as No. 736) are light salmon or light yellowish brown, thickly spotted with darker orange-brown, and with an interrupted pale streak over the stomach and reproductive organs.

Length of the larger specimens 12 to 18^{mm}; breadth 4 to 8^{mm}.

Description of specimens mounted in balsam:—The tissues are thin and fairly translucent. The pharynx has a large anterior, and a small short posterior lobe, with six principal lobes on each side. The mouth is nearly in the middle of the pharynx, but in advance of the middle of the body.

In the larger examples (Pl. XLIII, figs. 3 to 3*b*) the greater part of the body is filled with numerous ovarian and spermary vesicles, the

latter being more numerous and smaller than the former, and often grouped around them in clusters.*

The male genital orifice is far from the hind end of the body. The granular gland (*k*) is nearly round and prominent. The seminal vesicle (*r*) rests against the anterior side of the granular gland and consists of a central and two lateral parts, partially concealed by the granular gland, the exposed part being obovate or somewhat pyriform, as usually seen; the lateral portions are continuous with the *vasa deferentia* (*d*). The penis-sheath (*q*) is short, stout, somewhat conical; the penis itself, or verge, (*p*) is very long and slender, cirriform or hair-like, apparently somewhat chitinous, usually more or less coiled, often exsert in the preserved specimens.

The female genital orifice is usually surrounded by a broad circular pit. The first part of the duct (or vagina, *v*) is relatively large and long, a little expanded at the end, narrowing farther forward and bending upward and backward close to the male orifice, where it expands into a small ovate vesicle, from which it extends backward as a narrow moniliform tube (*v'*) which runs back beyond the external orifice and passes into the elongated cornucopia-shaped spermatheca (*s*), which is broad at the anterior, and pointed at the posterior end. In many specimens there appeared to be a small duct leading from the posterior end of the spermatheca to a minute external orifice (*x*), but this is uncertain, for it may be the nephridial duct.

Vineyard Sound to Eastport, Me., low-water mark to 42 fathoms or more. Abundant at Gloucester, Mass., on the shores, under stones, on the piles of wharves, and in tide-pools, especially at Ten Pound Island, 1878. Off Cape Ann, Mass., station 156, in 42 fathoms, muddy bottom, 1878 (No. 20). Casco Bay, Me., in tide-pools, 1873; Eastport, Me., in tide-pools and under stones at low-water mark, 1868, 1870, 1872. Vineyard Sound, on telegraph cable, off Cuttyhunk Island.

The original description of this species is almost useless for its identification. It is as follows: "This species is oblong-shaped, somewhat lanceolated, of a color varying from a light greenish yel-

* In the specimen (No. 20) illustrated (figs. 3–3*b*), the ovaries are colored light red, while the testes are colored dark red by the staining fluid used (alcoholic borax-carmine) and are, therefore, easily distinguishable. In order to prevent confusion, only a part of these organs are actually figured. The uterine sacs, oviducts, and most of the large sperm-ducts are also omitted, as well as the branches of the stomach, all of which can be seen, more or less distinctly, in the preparation.

low to an orange red, with a minute punctulation of a deeper red. The relative position of the eye-specks is subject to some variation. I have found it in Boston and Beverly harbors, always in deep water. It spawns in January and February. Entire length, half an inch."

The expression "deep-water" at the time the above was written probably meant 12 to 25 fathoms or less.

Although I have dredged extensively in the same waters where Girard's species was taken, and at all depths, I have never obtained any planarian that could be referred to his species with any probability of correctness, unless it be the species described above, which is a common one in Massachusetts Bay. There is nothing in Girard's description of specific importance except the color, which is more or less variable in all the species of the genus. Other species of *Leptoplana*, observed by me, are often tinged with reddish, or pale orange, but seldom so decidedly as his description would imply. Some of the varieties of the present species are, however, decidedly orange-red and have darker red or brown spots, nearly as stated in Girard's description. This fact, and the correspondence in locality induce me to adopt his name for this common species.

That his species was a *Leptoplana* is probable, because of his calling it a *Polycelis*, which, as used by authors at that time, was nearly equivalent to *Leptoplana*. From the description alone, it would, of course, be impossible to tell even the genus to which his species belongs, for no indication of the actual arrangement of the ocelli is given.

It is quite possible that this species is identical with *L. ellipsoides* Girard, described by him a few years later from the drawings of Dr. Stimpson. The latter, as it exists in the Bay of Fundy, is a much larger and broader form, with less conspicuous ocelli, and presents some other differences, as noted below. But these variations may be due to greater age, or to more favorable conditions of growth. My specimens are not sufficiently numerous to enable me to form a complete series between the two typical forms. They are, at any rate, very closely allied.

Among foreign species, the nearest relative of this species is, perhaps, *L. Dröbachiensis* (Œrsted) of Greenland. The latter has more numerous lobes to the pharynx and stomach, and differs, also, in the form of the genital organs.

Leptoplana ellipsoides Girard

Leptoplana ellipsoides Girard, in Stimpson, Invert Grand Manan, p 27, pl 2, fig 16, 1853, Diesing, Revision der Turbellarien, Abtheilung Sitz d mathem-naturw, xliv, p 533, 1861, Lang, Polycladen p 512, copy of original description

PLATE XI, FIGURES 5, 6, PLATE XLIII FIGURES 4, 4a 4b

Description of living specimens:—Body large, flat, rather thin, usually broad-ovate or broad-elliptical, but capable of becoming long-elliptical; the edges are thin and frequently strongly undulated, and are capable of being used for swimming by means of rapid undulatory motions.

Ocelli are small, black, and not very conspicuous; those in the dorsal clusters are larger than those in the cerebral clusters. The latter are relatively rather small, somewhat elongated groups, broadest near the middle, narrowing to a point anteriorly, and containing numerous (often 30 to 40) minute crowded ocelli They are situated a little forward of the other groups in usual states of the body, but in some states of contraction of the anterior and dorsal region they may be drawn back, so as to lie between, or even behind, the dorsal groups. The dorsal groups are usually nearly circular and contain numerous (20 to 25) ocelli of different sizes, some of which are much larger than the rest.

Color, various shades of dull yellowish brown, greenish brown, and reddish brown, usually more or less distinctly marked with irregular spots or blotches of darker brown, and with small specks of whitish; a lighter colored median streak runs over the gastric region, and another covers the genital region farther back; frequently the two streaks are united into a continuous median streak that extends nearly the whole length of the body. Under surface pale grayish or yellowish white, the whiter pharynx and *vasa deferentia* showing through indistinctly.

Length of large specimens, in extension, 25 to 35^{mm}; breadth 12 to 20^{mm}.

Description of mounted specimens:—The specimens mounted in balsam are not sufficiently translucent to show distinctly many of the internal organs, owing in part to their large size and the great amount of pigment, but more particularly to the fact that the body is so densely filled with ovarian and spermarian vesicles that the other organs are obscured.

The male genital organs (Pl. XLIII, figs. 4*a*, 4*b*) are close to the posterior end of the stomach; there is a conspicuous, nearly round, granular gland (*k*); at the anterior end of this, and partly concealed by it, the seminal vesicle (*r*) can be seen; its form is pyriform or rounded and cap-like, its length, as exposed, being usually greater than its breadth; it consists of a central, and two lateral parts, which are dilations of the *vas deferens;* the penis-sheath is stout-cylindrical or somewhat expanded at the end; the penis (*p*) is long and slender, cirriform, coiled up more or less in contraction; the external opening is often, in preserved specimens, raised on a conical elevation, and sometimes the penis sheath is protruded as a clavate papilla.

The female genital opening is usually situated in a broad funnel-shaped depression of the surface in preserved specimens; from this opening the nearly cylindrical, thick-walled, tubular duct or vagina (*v*) runs forward nearly or quite to the male orifice, where it bends upward and then turns backward upon itself in the shape of a siphon; at the bend it expands somewhat, into a small vesicle; but its distal or dorsal portion is a narrow, somewhat moniliform tube (*v*′), there being a series of slight constrictions along most of its length; it extends back beyond the external female orifice into a rather large, elongated, somewhat flask-shaped, thick-walled spermatheca (*s*). The first or ventral portion of the female duct (vagina, *v*) receives, on each side, numerous slender ducts of the tubular shell-glands that radiate outward from it in every direction, except directly forward. The connections of the uterine sacs or oviducts were not observed. Opposite the posterior end of the spermatheca there appears to be a minute external orifice that communicates by a slender duct with the spermatheca, but this connection was not fully demonstrated, nor was it seen in every specimen examined; it may be the nephridial duct.

Gulf of St. Lawrence to Casco Bay, low-water mark to 60 fathoms. Common at Eastport, Me., and Grand Menan, N. B., 1862 to 1872, at low-water mark under stones, in tide-pools, and at all depths down to 40 fathoms, on stony bottoms. Halifax, N. S., 8 to 10 fathoms, 1877. Casco Bay, Maine, 10 to 12 fathoms, 1873.

This species, as stated under *L. variabilis*, is closely related to the latter and may prove to be only a larger and more fully developed variety of it. The principal differences, externally, are the larger, broader, and more robust body, and the relatively smaller and much less conspicuous ocelli. The color is variable in each and not essentially different, unless the small white specks of the present species

be characteristic, which is doubtful. Internally, the structure is very similar, but the first part of the female duct (vagina) in this species is relatively shorter and smaller, and the spermatheca is somewhat swollen or flask-shaped, while that of *L. variabilis* is rather cornucopia-shaped. The male organs are very much alike.

The amount of the variations in form, proportions, and position of the genital organs that may be produced by the preserving and hardening fluids is, however, very uncertain. These closely allied forms should be more carefully compared as to these organs, when living, or at least before immersion in hardening agents.

Leptoplana angusta, sp. nov

PLATE XL, FIGURE 8, PLATE XLIV, FIGURES 2, 2*a*, 3.

Body very changeable, in extension rather narrow and elongated, elliptical or oblong, the length exceeding half an inch and equal to about three times the breadth, very thin, with the margins flexible, and usually more or less undulated and curled; the front end is usually rounded; the posterior end is often notched or emarginate in the middle.

The cerebral and dorsal clusters of ocelli blend, and form two nearly straight and parallel fusiform groups, often nearly linear in the small specimens, pointed at both ends, and situated well forward. In the larger specimens these groups have a distinctly wider portion behind the middle, composed of a small cluster of larger ocelli belonging to the dorsal groups, which are partially detached from the cerebral groups; but in the smaller specimens the dorsal ocelli can hardly be distinguished from the others, which mostly lie in two rows in each group.

The retracted pharynx is large, elongated, elliptical, with numerous short, nearly equal lobes along the sides, of which about twelve or thirteen pairs can usually be distinguished. The mouth is somewhat behind the center of the pharynx. The stomach has numerous lateral branches and a great number of terminal twigs which anastomose pretty freely distally.

The reproductive organs extend entirely around the pharynx and stomach, thus forming an opaque or dark colored elliptical zone. The *vasa deferentia* in the larger specimens are often conspicuous organs along the sides of the stomach. The uterine sacs in some specimens are large and swollen with masses of eggs, opposite and behind the posterior part of the stomach. The copulatory organs

are situated rather far back and are not easily seen in most of the preparations. The male organs consist of a large, elliptical, muscular penis-bulb more or less concealed by a large round granular gland ; the sessile, rounded or oval seminal vesicle is situated above and partly behind the anterior end of the granular gland ; the penis-sheath is rather long and large, cylindrical or sometimes elliptical ; the penis is, apparently, simple and conical, without a slender chitinous cirrus. The glandular portion of the siphon-shaped female duct is elongated and dilated anteriorly, in the largest specimens, and extends from near the posterior margin of the body forward to, and often beyond, the male orifice, as seen in the best preserved specimens. This region is usually so altered by contraction that the reproductive organs are evidently much altered in form and position in nearly all cases, and therefore vary in different specimens from the same lot. The larger specimens are filled with numerous ovarian and spermarian folicles, and the uterine sacs and *vasa deferentia* are swollen with their contents.

Color above, while living, various shades of light brown, often tinged with darker brown in the middle and at the margins.

Length, in extension, while living, 12 to 16^{mm}, breadth 4 to 6^{mm}.

Provincetown, Mass., 1879, abundant among hydroids, barnacles, etc , on the bottom of a whaling vessel, recently arrived from off the Carolina coast. It was associated with several southern species of mollusks, crustaceans, etc.

This species is not a typical *Leptoplana*, but it appears to be closely allied to several foreign species referred to that genus by Lang and others. In its external characters it agrees with the genus *Elasmodes* of Stimpson, which Lang unites with *Leptoplana*.

Trigonoporus Lang, op cit , p 502

Pharynx with numerous lateral lobes, stomach with about five or six pairs of main branches, which at first branch arborescently, but distally anastomose more or less completely.

Marginal ocelli numerous, but minute ; many other similar minute ocelli are scattered over the frontal region. Cerebral ocelli numerous, forming large clusters over the ganglions and frontal nerves.

Dorsal ocelli small and numerous, forming crowded groups, sometimes confused with the cerebral clusters. Male copulatory organ with a well developed pyriform penis-bulb and granular gland combined ; muscular penis-sheath conical or funnel-shaped ; penis simple, conical ; seminal vesicle apparently wanting. Female duct

siphon-shaped, with an external opening at each end. Its anterior opening is very near the male orifice (in contracted specimens often in the same depression); the posterior orifice is smaller and considerably farther back. A special spermatheca is wanting, or may be formed by a dilation at the anterior bend of the vagina, and not much specialized.

The single European species (*T. cephalophthalmus*), for which this genus was constituted, is a long and narrow form, with the groups of ocelli all confused, while our two species are broad and stout forms, with the four main clusters of ocelli clearly distinct, and arranged much as in *Leptoplana* and *Cryptocelis*, from which they differ but little in general appearance, when living. From *Leptoplana* they are, however, easily distinguished by the presence of numerous marginal and frontal ocelli, and by the peculiar structure of the genital organs. In the structure of the reproductive organs, and especially in having two orifices for the female duct, both of our species agree well with the type-species of *Trigonoporus.*

The cerebral ganglions and main nerve-trunks in both of our species are distinctly pale red in life, the color resembling that of the nervous system of certain nemerteans belonging to the genera *Lineus* and *Cerebratulus.* This observation was repeated many times, and in different years, so that it can scarcely be due to any temporary cause. I have not observed a red color in the nervous system of any other planarian.

Trigonoporus folium Verrill

Leptoplana folium Verrill, Marine Invert of Vineyard Sound, etc, pp 632 [338] 1873, Lang, op cit., p 512, copy of original description

PLATE XLI, FIGURES 5, 5a, 3; PLATE XLII FIGURES 5, 5a, 5b, PLATE XLIV FIGURES 4, 4a, 4b, 4c, 4d, 5b, 6, 7

Description of living specimens:—Body very changeable in form, rather flat, leaf-like, in extension oblong-elliptical or ovate, and usually narrowest anteriorly, capable of contracting to short, rounded or broad-ovate forms; margins more or less undulated, when in rapid motion.

Ocelli small and rather inconspicuous; the dorsal groups are situated at about the anterior fourth or fifth; the cerebral groups are elongated, irregularly fusiform, there being two broader portions, united by a narrower one, in the middle of each; they taper to a point at both ends, with numerous minute ocelli in the broader parts, near the middle and over the front and posterior ends of the gan-

glions; they are nearly parallel, not far apart, extending both behind and before the brain, but diminishing in breadth over the middle of the ganglions; one or two of the anterior ocelli are usually distinctly larger than most of those in the clusters. The smaller but more conspicuous dorsal groups, which are a little farther apart and situated rather behind the ganglions, contain a moderate number of rather larger ocelli, forming somewhat angular or irregularly rounded clusters, while just behind each group there is usually a small detached cluster of two, three, or more ocelli. In some specimens these small clusters are not noticeable, while in others they nearly blend with the main clusters.

The mounted specimens show, also, two, three or more rows of minute marginal ocelli, extending around the anterior margins, back to the middle of the sides, and in small numbers even to the posterior end; many other similar minute ocelli* are scattered over the whole frontal region, in advance of the cerebral groups, and some of the largest of these are ranged along the main frontal nerves.

Color, in life, yellowish flesh-color or pale ocher-yellow, lighter or darker yellowish brown, etc., becoming paler and translucent near the margins which are whitish; the ganglions and main nerves are pale red or pink; the stomach has very numerous, much lobed and divided branches, which often show through as brown markings; over the stomach and pharynx there is a whitish or pale reddish streak; behind the gastric streak there is a small elliptical whitish patch over the genital organs. The ventral surface is paler and shows a whitish gastric spot and the opaque *vas deferens* running up along each side of the stomach.

Length in life, 18 to 25^{mm}; breadth 10 to 15^{mm}.

Description of specimens mounted in balsam:—The ocelli, in the mounted specimens (Pl. XLIV, figs. 4*b*, 5*b*), appear more numerous than in the living ones, because more of those that are situated deep in the integument become visible, and consequently the shape of the clusters, especially the cerebral ones, appears to be different, in addition to the effect of contraction. The brain (fig. 5*b*) is only slightly bilobed. The stomach-branches are so thoroughly anastomosed that the body-parenchyma, as seen by translucency, appears to be vermiculated, or divided in many places into polygonal compartments, in some places even having a honey-combed appearance while in

* These small scattered and marginal ocelli were not noticed in the living specimens, doubtless owing to their small size. The examinations were mostly made with a good pocket lens, or a dissecting microscope.

other parts the spaces are rosette-like; owing to the contraction of the tissues the surface is reticulated by corresponding grooves. The ovaries and spermaries when present are numerous and arranged somewhat in rosettes, but they are not developed in most of the specimens, even when of large size.* The granular gland and muscular penis-bulb together form a conspicuous, broad-pyriform organ (Pl. XLIV, figs. 4, 4*a*, 6, 7, *k*), which is partially translucent and shows a radially vermiculated structure within (*k'*) and a central funnel-like opening to the ejaculatory duct; the anterior, opaque, rounded, glandular portion, forms, in some specimens, a slight median angle, or prominence. The muscular penis-sheath (figs 6, 7, *q*) is strong and usually regularly funnel-shaped. The penis (*p*) is small, tapered, styliform.

The anterior female pore is near the male orifice, and in some specimens, owing to contraction of the tissues, both are brought close together into a single pit-like depression (figs. 4, 7); the dorsal portion of the female duct (*u'*) is somewhat elongated, and its posterior opening is at a considerable distance from the anterior orifice; the ventral part of the duct (*v*) is shorter and broader, and it receives the ducts of numerous shell-glands (*w*); at its upward bend it is considerably dilated, and this part probably serves as a spermatheca.

Behind the second female orifice (♀') there is usually visible a slender median duct which appears to terminate in a minute median pore (*u*); this is, perhaps, the central nephridial duct, but its extension forward could not be traced in the preparations.

The *vasa deferentia* are large and convoluted, in the specimens containing ova, and extend forward to or beyond the middle of the stomach. The uterine sacs, in the same specimens, are large and moniliform, each one containing four or five rounded masses of eggs; they extend forward to about opposite the mouth.

In the sexually developed specimens the spermaries are very numerous, especially between the outer meshes of the gastric branches, where there are few ovaries; farther toward the center they often form groups of five to ten around a single ovarian folicle, thus having the appearance of a rosette, with the larger ovarian folicle in the center, each rosette occupying one of the meshes formed by the digestive tubes.

Long Island Sound to Eastport, Maine, from low-water mark to

* Probably the breeding season was mostly past when they were collected, in midsummer, but they are present in the original specimen obtained in April, and also in the one from station 784.

54 fathoms. Off Watch Hill, R. I., 4 to 6 fath. among algæ, specimen with ova, April, 1872 (A. E. V.); off Point Judith, R. I., sta. 784, in 20 fath., with ova, 1880; off Block Island, sta. 812, 28½ fath.; off Gay Head, Martha's Vineyard, 18 fath., 1887; off Cape Cod, sta. 301, 27 fath., 1879; off Cape Ann, Mass., at stations 134 and 136, in 26 fath., and at sta. 182, in 45 fath., 1878; Eastport, Maine, 1870.

There is considerable variation, both in external appearance and in the form of the reproductive organs in this species, but I believe the differences observed are due to age, season of the year, presence or absence of ova, and the amount of contraction when preserved. As it might be doubted whether all the forms can be referred to *T. folium,* I have thought it well to give here a special description of the original type-specimen of that species, for comparison with the later and better specimens, described above.

Description of the original specimen from life:—Body very flat, foliaceous, with the margin thin and undulated; outline very changeable, broad-ovate, narrowing to an obtuse point at the anterior end; sometimes oblong or elliptical and but little narrowed anteriorly.

Ocelli in four groups, near the anterior end; the anterior or cerebral clusters are parallel, narrow, elongated, widest in the middle, close together, almost blending on the median line, and composed of many very minute ocelli, less easily seen than those of the other clusters; the terminal ocelli are largest; the dorsal or posterior groups are rather small and irregular; in some states of extension often triangular, with the pointed end backward; marginal ocelli numerous, but minute, in two or three rows near the edge, with others scattered over the frontal region, visible only when much magnified.

Color, pale yellowish flesh-color, veined with dendritic streaks of darker flesh-color and whitish lines; an interrupted longitudinal whitish streak in the middle, over the stomach and pharynx, and a small median whitish streak farther back.

Length, 20^{mm} to 25^{mm}; breadth, 10^{mm} to 15^{mm}.

Off Watch Hill, 4 to 6 fathoms, among rocks and algæ, April, 1872.

Description of the original type as preserved:—This original type-specimen, mounted in balsam, shows many of the anatomical characters (Pl. XLIV, figs. 4–4c), but the posterior end had been mutilated in life and only partly healed; in consequence of this the female reproductive organs are not perfect. This also accounts for the broad emargination of the posterior end, mentioned in the original description.

The pharynx is short and broad and has five large lobes on each side, some of which are bilobed, and two small lobes near the anterior end. The mouth is somewhat behind the middle of the pharynx. The stomach has five or six main branches on each side and these are much branched and extensively anastomosed distally, as described above.

The meshes or interspaces between the stomach-branches are filled with large numbers of rather large ovarian folicles and a much greater number of smaller spermaries which are grouped closely around each of the ovarian folicles, so as to form rosettes where they are not too much crowded; distally the spermaries increase in numbers, while the ovaries diminish.

The combined granular gland and penis-bulb (figs. 4, 4*a*, *k*) form a regularly pyriform organ, rounded anteriorly, and having essentially the same structures as in the specimens described above; the penis and penis-sheath (*q*) also agree well with those already described. Owing to the mutilation of the female organs and the contraction of the parts, the anterior female orifice and the male orifice are brought close together, and the posterior female orifice is not distinguishable.

This is a very active and restless species. One specimen protruded its multilobed pharynx when placed in alcohol. A specimen (sta. 136, July 26, 1878) was filled with white eggs, visible through the integument of the ventral side, while living.

When preserved in alcohol, the specimens retain their form better than those of most of the related species, and usually do not curl up much; the preserved specimens are rather thick, firm, usually broad-ovate, narrower toward the front end, which is often somewhat lanceolate; the mouth is usually visible as a small round central opening; the small male reproductive orifice, or a papilla in its place, is often distinct.

Trigonoporus dendriticus, sp. nov.

PLATE XLI, FIGURE 4; PLATE XLII, FIGURES 4, 4*a*, ~~4b~~; PLATE XLIII, FIGURE 5.

Body usually ovate with the anterior end narrowed and more or less pointed, edges undulated and flexible, but the form is subject to considerable changes, though less so than in the species of *Leptoplana*.

Ocelli minute and rather inconspicuous; the cerebral groups are near together, irregular and somewhat elongated, composed of numerous very small ocelli which mostly lie over the anterior and

the posterior ends of the ganglions, so that each cluster is constricted in the middle, or somewhat hour-glass shaped; the dorsal groups are more conspicuous, but usually smaller, irregular, longer than broad, often somewhat elongate-triangular, with the acute end directed backward;* they are well separated from the cerebral groups and are, for the most part, behind them; marginal ocelli are small but numerous, in two or three rows extending back to the middle, while numerous small ocelli are scattered over the whole frontal region.

Color pale yellowish or pinkish, with brown dendritic markings, due to the much divided and lobed stomach branches; the pharynx, showing distinctly through the integument, forms a deeply lobed central spot. The cerebral ganglions and nerves are reddish. The mouth is rather large, situated in front of the middle, and about opposite the second pair of large pharyngeal lobes. Pharynx is large and has about five pairs of large and long lobes. The main branches of the stomach fork and divide arborescently at first, and the branches are much lobulated along their sides, giving them a fern-like appearance. They do not anastomose so freely as those of *T. folium.*

Length 12 to 15^{mm}; breadth 6 to 8^{mm}.

The reproductive organs (Pl. XLIV, fig. 3) agree pretty nearly with those of *T. folium*, as seen in the mounted specimen. The penis-bulb and granular gland together are more oblong than in that species, and there appears to be a constriction near the front end, partially separating the cap-like anterior portion from the rest. The penis is short, conical, and simple; its sheath is not so thick and strong as in *T. folium*. The anterior female orifice is a little distance back of the male orifice; the glandular part of the vagina is elongated, and its posterior orifice is situated well back.

Off Race Point, Cape Cod, sta. 317, in 25 fathoms, 1879.

Discocelis Ehrenberg, 1832, (emend.), Lang, op. cit., p. 466.

Body broad, usually ovate, foliaceous, marginal ocelli present, cerebral and dorsal ocelli variable in number, usually in four groups. Mouth central or a little in advance of the center. Pharynx large, and sometimes with divided accessory pouches. A single common

* The mounted specimens, as well as some of my sketches from life, show that all the groups of ocelli as represented in fig. 4, Plate XLI, are too regularly triangular, and the posterior groups are too large and too elongated; the enlarged figure on Plate XLII, fig. 4*a*, is from the same specimen, after mounting, but doubtless the shape of the groups is more or less altered by contraction.

genital opening. Female genital organ with a glandular accessory vesicle.

The following species is referred to this genus chiefly on account of its external resemblance to the typical species. I have had no mature specimens sufficiently well preserved to enable me to study the reproductive organs.

Discocelis mutabilis Verrill.

Polycelis mutabilis Verrill, Report on the Inverteb. of Vineyard Sound, etc., p. 746, (452,) 1873.

Lang, op cit, p. 616, copy of original description.

PLATE XL, FIGURE 7; PLATE XLII, FIGURES 6, 6*a*, 7.

Description of the original specimen from life:—Body much depressed, thin, changeable in form, often elliptical or oval, frequently broad and emarginate in front, and tapered posteriorly. Marginal ocelli very distinct, black, forming several rows along the front border, but only one or two rows laterally. Dorsal and cerebral ocelli larger, forming three pairs of rather ill-defined clusters; the outer or dorsal clusters are largest, often convergent backward; a pair of smaller cerebral clusters is situated a little in advance, and nearer together; the third pair is a little farther forward and still closer together, often more or less confused with those next behind them.

Color, yellowish brown, darker centrally; or pale yellowish, thickly specked with yellowish brown. Length, about 7 to 9^{mm}; breadth, 5 to 6^{mm}.

Thimble Islands, near New Haven, Conn., 1 to 2 fathoms, among red algæ, 1872.

The original type-specimen, described above, was mounted in balsam for the microscope, when first obtained. It is still in my possession, and from it the figures (Pl. XLII, figs. 6, 6*a*) have been drawn with the camera-lucida. Unfortunately the internal organs are not well preserved. The reproductive organs cannot be seen at all. Possibly the specimen was immature, with imperfectly developed sexual organs, but its size would indicate that it was adult.

The pharynx and stomach are large and have numerous lateral lobes. As near as can be made out, the elongated stomach has eight or nine principal branches on each side, but they are indistinct, owing to the poor state of preservation of the specimen.

The marginal ocelli are rather conspicuous and extend back nearly as far as the posterior end of the stomach. The four groups of

cerebral and frontal ocelli are more or less confused in the preparation, and are unusually far apart, doubtless owing to compression in mounting the specimen; the distortion of the groups is doubtless due to the same cause; behind each cerebral group there is a rather large isolated ocellus. The posterior or dorsal groups are conspicuous, a little elongated, elliptical or oval, somewhat pointed behind; each is composed of about 12 black ocelli, several of which are considerably larger than the others, reniform in shape, with a transparent, lens-like portion on the concave side.

I have never found another large specimen that can be referred to this species.

Description of young specimens:—Several very young individuals were taken at the surface, with towing nets, both at Newport, R. I., and at Wood's Holl, Mass., which apparently belong to this species, but they are all too immature to be identified with certainty, until intermediate sizes shall have been observed.

One of these young specimens, figured from life, is represented on Plate XL, figure 7, in its contracted form; another unpublished figure of the same individual is considerable longer with the frontal ocelli farther forward, and with the stomach longer and showing eight or nine pairs of lateral branches. The reproductive organs are not distinctly developed. The form is generally obovate or obcordate, with a distinct emargination in front. The ocelli form six groups; the frontal groups contain each only one or two ocelli; the cerebral groups contain each about three ocelli in a single row; each of the outer or dorsal groups contains three ocelli. (Pl. XLII, fig. 7).

The color is translucent whitish with delicate, pale yellow dendritic marking and a deeper yellow gastric spot; the transparent margin is elegantly marked with a row of light golden yellow spots. It is active and graceful in its movements.

This specimen was taken at the surface of the sea at Wood's Holl, Aug. 16, 1882.

Tribe, COTYLEA Lang.

Acetabulum ventral, behind the female opening.* Mouth and pharynx situated between the middle and anterior end of the body.

* The existence of a ventral acetabulum or sucker is not strictly diagnostic of this group, for certain species of *Leptoplana* and of *Planoceridæ* have, also, a ventral sucker of the same kind. But in all the latter groups, so far as I know, the sucker, when present, is in front of the female orifice Perhaps the pit-like depression around the female orifice of certain species of *Leptoplanidæ* is of the same nature and for the same purpose.

Pharynx tubular, long or short, exsertible. Main stomach cavity not extending forward beyond the pharynx. Lateral branches of the stomach variable in number, reticulated or dendritic.

Tentacles, when present, situated at the anterior margin, often wanting. Ocelli numerous, usually forming two cerebral clusters; an anterior marginal row; and clusters in the tentacles, when these are present. Female organs are without a copulatory pouch and accessory vesicle or spermatheca. The male organs are variously situated, often anterior; sometimes they are paired, or even (in the genus *Anonymus*) multiple in a lateral row along each side. Development with metamorphosis.

Family, Euryleptidæ Stimp., 1857 (emend.).

Euryleptidæ Lang, Die Polycladen des Golfes von Neapel, p 553, 1884

Body ovate or elliptical. Marginal tentacles present or absent. Mouth near the anterior extremity of the body. Pharynx tubular. Stomach long, narrow; its branches either simple or anastomosing. Ocelli are present at the front margin of the body and in the tentacles, when these are present; others form two cerebral groups.

Eurylepta (Ehrenberg) Lang.

Body not papillose. Marginal tentacles well developed, elongated, not pliciform. Pharynx cylindrical. Principal lateral branches of the stomach about five on each side, not anastomosing. Male aperture under the posterior end of the pharyngeal sac.

Eurylepta maculosa Verrill, sp nov

Plate XLI, figures 2, 3

Description of living specimens:—Body thin, very changeable, usually elliptical or oblong, and more or less elongated, with the margin very thin; in motion often wavy and undulated, and constantly changing its form; frontal margin rather narrow with two moderately long, obtuse, flattened marginal tentacles, which are flexible and changeable in form.

Ocelli numerous; on the lower and anterior sides of the tentacles there are clusters of numerous, minute, black ocelli, but they do not extend much above the middle of the tentacles; numerous similar marginal ocelli are scattered between the tentacles on and near the front margin; back of the tentacles, the distance varying with the state of contraction or extension, there are, above the ganglions, two elongated groups of cerebral ocelli, side by side, and so close together as to appear, at times, like one broad group; each of these groups

consists of twelve or more ocelli, of which one, near the middle in each group, is larger than the rest.

Color pale, translucent, yellowish or pinkish white, irregularly specked and mottled, or veined, with purplish or brown, and usually with a number of darker and more distinct, small, brown spots scattered over the central area, and especially along the middle of the back, while around the margin the color markings form distinct radial spots.

Length 10 to 12^{mm}; breadth 6 to 8^{mm}.

Wood's Holl, on piles, July 14, 1881; in mud, Aug. 2, 1882; Naushon I., near Wood's Holl, Mass., at low-water mark, among algæ, Aug. 20, 1887.

This species has been met with but few times, and in each case only a single specimen has been obtained. It must be considered very rare on our coast. None of the specimens are sufficiently well preserved to allow any anatomical study.

Family, Prosthiostomidæ Lang, p. 594.

Prosthiostomum Quatrefages, op cit, p 133, 1845, Lang, op cit, p 594

Body elongated, smooth. No tentacles. Ocelli in cerebral groups and around the front margin. Mouth anterior, below the brain. Pharynx long, tubular, directed forward. Stomach elongated, with numerous lateral branches, not anastomosed.

Male genital organs behind the pharyngeal sac; two accessory seminal vesicles; penis uncinate, directed backward.

This is the only genus of the family.

Prosthiostomum gracile Girard.

Prosthiostomum gracile Girard. Proc Boston Soc Nat. Hist., vol. iii, p. 251, 1850.
Elasmodes? gracilis Stimpson, Prodromus, p. [3] 21, 1857.

Woodcut, Fig. 1

The original description of this species is so meager that no one has hitherto been able to identify it, so far as I know.

It reads as follows: "It differs from other species of the same genus by its very slender body and the arrangement of the eye-specks, which are disposed in four groups; of which the first and second are in a single pair, the third triple, and the fourth double. From Boston Harbor."

The generic position has been doubtful. Dr. Stimpson, who states that he had Girard's original drawings of planarians for examination, refers it doubtfully to *Elasmodes* (= *Leptoplana* in part).

The only specimens of the genus *Prosthiostomum* that I have found on the New England coast are quite young. Presuming that Girard's species was correctly referred to this genus, my young specimens may, very likely, belong to the same species, for the ocelli have a similar arrangement.

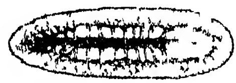

Fig 1 *Prosthiostomum gracile*. Young × 8

When living the body is long-elliptical in extension (see cut 1, from life) and quite thin and translucent. The stomach has about fourteen main branches on each side, and these are much divided distally. Those of the anterior pair curve outward and forward around the pharyngeal region and ocelli. The tubular pharynx was only imperfectly seen, and was probably not fully developed. The cerebral ocelli form an interrupted curved row of about four on each side, of which the anterior pair is largest. The posterior or dorsal clusters are each represented by two ocelli, placed obliquely. The marginal ocelli are very distinct, and form a single row around the front edge. The reproductive organs were not developed.

Color pale yellowish white with darker yellow arborescent markings, due to the gastric branches. Other specimens are light yellowish green, with a whitish gastric spot and pale radial lines, and a greenish median line posteriorly.

Length of the largest about 4^{mm}; breadth $1{\cdot}25^{mm}$.

Noank, Conn., July 9, 1874; Wood's Holl, Mass., July 25, 1881; New Haven, Conn., Oct. 14, 1892. Boston Harbor (Girard).

It is probable that Girard's specimens were also immature, and perhaps but little larger than those here described. He does not give the size.

MONOGONOPORA or TRICLADIDEA.

Body generally narrower and relatively longer than in the *Digonopora*. Sometimes a distinct muscular ventral foot is present. Sometimes a posterior sucker is developed. In some genera there are dorsal tentacles; in others, frontal lobes. The mouth is generally somewhat behind the middle. The pharynx is generally simple*

* In the American fresh-water genus *Phagocata* (Leidy), besides the central pharynx, there is a row of smaller ones along each side, each one arising from the base of a lateral secondary stomach-branch.

and tubular, often cylindrical or urn-shaped, and capable of being protruded fully from the mouth ; when retracted it lies in the median line, in a definite pharyngeal cavity. Its base connects with the stomach at the central part from which the three main gastric branches arise.

Two of the main gastric branches run backward, one on each side of the pharyngeal and reproductive regions, and from these numerous smaller transverse branches, either simple or branched, run out toward the margins, and still smaller transverse branches often run inward toward the center. The anterior main branch is median and gives off lateral branches more or less symmetrically on each side.

The brain, frontal nerves, and main lateral nerve-trunks are generally well developed ; a small marginal nerve and a complex nervous plexus can often be distinguished without difficulty.

The ocelli are often only two, situated over or near the cerebral ganglions, in other cases three pairs, and in many genera they are numerous, in two groups ; sometimes they are lacking. A median otocyst is sometimes present.

The species are nearly all hermaphrodites. There is one common genital orifice, posteriorly situated. The ovaries, or *germaria*, are usually two, anteriorly situated, and special *vitellaria* are developed along the sides. Spermaries are generally, but not always, numerous and scattered. The copulatory organs present many variations. The eggs are generally enclosed in capsules. Some species are viviparous. Development is direct.

Most of the species of this group inhabit fresh-water and moist places on the land, but there are several marine genera. The terrestrial species are found chiefly in warm and moist countries, but a single, small terrestrial species (*Rhynchodemus sylvaticus* Leidy) inhabits New England, as far north as New Haven, where I have often observed it.

Family, Bdellouridæ Verrill.

Bdelluridea Diesing, op. cit., p. 518, 1861.

Body elongated, flattened, highly muscular, leech-like, with a well developed posterior acetabulum or sucker. Brain and lateral nerve-trunks well developed ; marginal nerve distinct. Pharynx plicated, cylindrical in extension. Two posterior main gastric branches not united posteriorly. Ectoparasites.

This family is constituted for the following genus only.

Bdelloura Leidy.

Proc Acad. Nat. Sci. Philad, vol v 242, 1851; Stimpson, Prodromus, p 6, 1857.
Bdellura Diesing. Sitzb. der mathem-naturw, Abtheilung, Dendrocœlen, p. 518, 1861

Body flat, lanceolate, with thin muscular edges along the middle, adapted for swimming. Acetabulum nearly as wide as the body, separated by a constriction. Mouth behind the middle. Tentacles none. Ocelli two, reniform, with a front lens. Brain large, bilobed, with several pairs of frontal nerves; lateral nerve-trunks (Pl. XLIV, fig. 8, *n*, *n'*,) large, united by a posterior commissure in the acetabulum, and by others, farther forward, behind the genital orifice. Lateral gastric branches (fig. 8, *g'*) more or less divided. Penis simple, conical, unarmed (figs. 8, 8*a*, *p*). A pair of female, accessory, lobulated glandular organs or "uterine sacs" (fig. 8, *x*) is situated about opposite the genital pore. Unicellular mucus-glands are present. Rhabdites are wanting. Eggs are enclosed in capsules.

The only known species is an active ectoparasite on *Limulus*, but it is able to swim freely, with an undulatory, leech-like motion.

Bdelloura candida Girard.

Vortex candida Girard, Proceedings Boston Soc. Nat Hist, vol. iii, p. 264, 1851.
Bdelloura parasitica Leidy, Proceedings Acad. Nat Sci. Philad., vol. v, p 242, 1852; Stimpson, Prodromus, p. 6, 1857
Bdelloura candida Girard, op. cit., vol. iv, p 211, 1852
Bdellura parasitica Diesing. op cit., p. 518
Bdelloura candida Verrill, Rep Marine Invert. Vineyard Sound, pp 634 [340], 460 [166], 1873. Gissler. Amer. Nat., vol. xvi, pp. 52, 53, 1882 (egg-cases and young), Ryder, op cit., pp. 48–51; 142, 143, 1882 (10 woodcuts of egg-cases, etc; fig. 8 is reversed, head for tail), three species supposed to exist on *Limulus*.
Planaria limuli Graff, Zool. Anzeig., pp. 202–205, 1879, Woodruff, Bull. Mus. Comp. Zool., xxi, p. 19, 1891.

PLATE XL, FIGURES 10, 10*b*, PLATE XLI, FIGURE 8, PLATE XLIII, FIGURE 11; PLATE XLIV, FIGURES 8, 8*a*, 8*b*.

Body smooth and firm; muscular system highly developed; very changeable in form and very active; usually lanceolate, or broadest in the middle with the anterior end pointed. While adhering by the posterior sucker it can extend itself in every direction, at times

Fig. 2. *Bdelloura candida.* Adult, slightly enlarged.

becoming almost linear and looking very much like a small leech (*Clepsine*), but in contraction it becomes short-elliptical, oval, or oblong; the margins are thin and often undulated in life. Posterior

sucker well-developed, variable in form according to the state of contraction. It is able to swim rapidly with undulatory motions like those of a leech.

Ocelli two, black, conspicuous, near together, not far from the front end. Pharynx conspicuous in life, as a white median, cylindrical, sulcated organ showing through the integument; its open end is divided into about six small lobes. Mouth nearly central, or a little behind the middle. Transverse branches of the intestine numerous and crowded, about twenty-five to thirty principal ones on each side; mostly forked and lobulated distally, in adult specimens. The ovaries or germaria appear as somewhat opaque, whitish, round or pyriform organs near the bases of the fourth pair of branches of the stomach, and often about midway between the brain and the base of the pharynx.

Color whitish, grayish, or yellowish; the intestinal branches usually forming a central darker brown region, in the middle of which the pharynx forms an oblong white spot. The color of the gastric or intestinal branches varies according to their contents.

Length 15 to 25^{mm}; breadth 4 to 6^{mm}.

Cape Hatteras, N. C., to Casco Bay, Maine. Very common on the gills and gill-plates and other parts of the "horse-shoe crab," *Limulus polyphemus.*

The egg-capsules* are often found in large numbers attached to the gill-plates of *Limulus.* They are chitinous, brownish or yellowish, variable in size and form, usually oval, elliptical, or oblong, with the upper side convex and the under side nearly flat; the larger ones are about 3^{mm} long and half as wide. Pl. XLIV, figure 8*b*. They are usually attached by a pedicle at one end, but sometimes at both ends. They contain from one to eight eggs or embryos, most commonly four to six. I have observed fresh capsules during the whole summer, and have seen them forming in October, showing that the breeding season is long. Pl. XLIII, fig. 11, *ca.*

It seems to me certain that the embryos formerly described and

* Dr J. A. Ryder has described and figured three forms of these egg-capsules from the gills of *Limulus* (Amer. Naturalist, vol 16, pp. 48–51) and thinks that they probably belong to distinct species. I have never found but one species of adult planarians on *Limulus.* In the case of one of the worms (fig. 8), supposed by him to be a distinct species, he mistook the caudal sucker for the head, and overlooked the eyes. Making this correction, the differences noted by him disappear. The differences in the capsules appear to be only variations of form and size of no great importance due, in part at least, to the age and size of the individuals producing them. The capsules produced by the largest specimens contain more ova than those belonging to young individuals.

figured by Mr. A. Agassiz,† under the name of *Planaria angulata*, did not belong to this species, for he stated that the eggs found by him were in "a string of eggs, mistaken at first for those of some naked mollusk," which is the case with the eggs of many Polycladidea, but not with those of this genus. The embryos observed by him were not sufficiently advanced for identification, but the structure of the stomach and its branches, so far as developed, agrees better with one of the Polycladidea than with that of any of the Tricladidea. The embryos of *Bdelloura* before leaving the capsules usually have the three main divisions of the stomach clearly visible, as well as the two eyes.*

This is a true parasite. It sucks the blood of its host and destroys the substance of the gills. When large numbers are present the gills of the *Limulus* are often extensively damaged in this way.

It is gregarious in its habits. Large clusters of the adults are often found grouped together on the joints of the legs as well as on the gills of *Limulus*. Even in confinement they preserve the same habit, adhering to the glass in large groups. When disturbed they often swim away with undulatory motions, like certain leeches.

This species is particularly favorable for anatomical studies, for the tissues are well differentiated and the various organs are more distinct than in many other allied planarians. The small amount of pigment in the integument is also favorable, especially when examined in the living or fresh condition. It is also very tenacious of life, for it will live for a long time without food in a very small amount of sea-water.

Some of the principal anatomical characters that can be made out with living specimens are represented on plate XLIV, figs. 8, 8*a*. Figure 8 shows a ventral view of the entire worm only slightly compressed, and figure 8*a* shows the posterior portion of another individual more strongly compressed, so as to show the reproductive organs better, but in this figure the intestinal branches (*g'*) are so much compressed that they appear unnaturally broad and swollen, while the outline of the posterior sucker is obscured, for the same reason. In this figure the nervous system is omitted.

The lateral gastric branches (left unshaded in fig. 8) in adult specimens are very numerous, ten to twelve arising from each side of the anterior trunk or median division of the stomach (*g*), while

* Several writers, have carelessly referred to the embryonic forms, described by Mr. Agassiz, as the young of this species, although the true egg-capsules of the latter have long been known

† Annals Lyceum Nat Hist., New York, vol viii, pp 306–309 1866

twelve to eighteen arise from each of the posterier divisions (g'). Those in the middle part of the body are mostly two-lobed or forked, and some of them are divided into three or four branches but some remain simple, especially toward the ends of the body. Under pressure all the branches usually appear lobulated along their sides and at their ends. The posterior trunks also give off from their inner borders smaller lateral branches which run in toward the median line, where those of opposite sides anastomose, back of the pharyngeal region. The two posterior trunks do not anastomose at their posterior ends in any of the examples studied by me. The anterior trunk terminates behind the brain.

The pharynx (f) is large, cylindrical or urn-shaped, according to its state of contraction, lobed or scolloped at the end, and often plicate or grooved along the sides. It is often protruded in alcoholic specimens

The bilobed brain (c) is large and easily seen. Each lobe gives off from its antero-lateral and front borders about five main nerves (c') which subdivide and run to the margins of the head The main lateral nerve-trunks (n, n') are large and distinct They run back and anastomose directly in the posterior sucker. They give off, all along their course, lateral nerves that subdivide into many small branches, part of which go to the adjacent organs, while some go to and join the small but distinct marginal nerve (n''), in the vicinity of which they form a fine network. The principal transverse branches from the large nerve-trunks correspond nearly in number with the gastric branches. Back of the genital organs five or six, or more, transverse commissures unite the main nervous trunks. The eyes are well developed, with a blackish, reniform, pigmented retinal body and a frontal lens like structure.

The genital orifice (♀, ♂) is situated just back of the pharyngeal region. The *vasa deferentia* (d) run alongside of the pharyngeal region as convoluted tubes; near the penis they become enlarged and serve as two seminal vesicles (r). The penis-bulb is pyriform or obconic, and the penis (p) is simple, styliform. The oviducts run forward from the female genital duct or vagina (v) on each side to the germaria or ovaries (♀ fig. 8), which are situated well forward at or near the bases of the third and fourth pairs of gastric branches. The vitellaria or yolk-glands are very numerous; they are clustered around and between the gastric branches, together with the testes or spermarian folicles (t, t), which are smaller and more numerous.

Two rather conspicuous glandular organs or "uterine sacs" (x) are situated to the right and left of the genital orifice. Each one is connected with the genital duct by a convoluted tube. The function of these organs was not clearly ascertained, but they probably are of the same nature as the so-called "uterine sac" of other tricladial planarians, which serves in part as a spermatheca or seminal receptacle and in part as a shell-gland. In this genus their principal function is probably the secretion of the materials for the formation of the strong, chitinous egg-capsules.

Family, PLANARIDÆ.

Body depressed, more or less elongated, often oblong or long-lanceolate in extension. Head sometimes broader than the body, often with its lateral or antero-lateral margins a little produced into points or angles, or somewhat auriculate. Tentacles sometimes present, usually absent.

Ocelli commonly a single anterior pair, with a frontal lens-like portion and a reniform pigmented body; sometimes three or more pairs; sometimes absent.

Pharynx single,* tubular, usually cylindrical; mouth central or subcentral. Lateral intestinal branches simple or dichotomously divided.

Eggs commonly laid in capsules. Some species are viviparous. Fluviatile and marine.

Fovia Girard; Stimpson, emend., 1857

Fovia Girard Proc Boston Soc Nat Hist, iv, p 211. 1852, Stimpson Prodromus, p. vi, 1857; Diesing, op cit, Dendroc, p 501, 1862, Jensen, Turbellaria ad Litora Norvegiæ p. 74. 1878

Body depressed, oblong or long-elliptical in extension, changeable; back a little convex, ventral side flat, the posterior part most muscular. Front of head often slightly produced and angular; sides of head rounded, at other times a little prominent or angular.

Ocelli two, anterior, rather large, with front lens and reniform pigmented body, each usually surrounded by a pale spot.

* The fluviatile genus *Phagocata* Leidy is here excluded from this family. It should be the type of a special family (*Phagocatidæ*) characterized by the presence of numerous secondary lateral pharynges, besides the median central one, and by several other peculiarities of structure. (See detailed description of its anatomy and histology by W. M. Woodworth, in Bulletin Museum Comp. Zool., vol. xxi, pp. 1-44, pl. I-IV, 1891.)

Mouth near or behind the middle. Largest lateral branches of the stomach usually more or less lobed or forked in the adult, simple in the young. Pharynx large, cylindrical. Reproductive organs not fully known. Penis conical, simple.

This genus appears to be closely related to *Gunda*.

Fovia affinis (Œrsted) Stimp.

Planaria affinis Œrsted, Entw. syst. Einth Plattwürmer, p. 54.

Fovia affinis Stimp., Prod., p [6] 24, 1857; Diesing, op. cit., p. 502, 1861, Jensen, op. cit., p 74 (descr.)

? *Vortex Warreni* Girard, Proc. Boston Soc. Nat. Hist., vol iii, pp. 264, 363, 1851.

? *Fovia Warreni* Girard, op. cit., vol. iv, p. 211, 1852; Stimp. Prod., p. [6] 24, 1857; Diesing, op. cit., p. 229, 1862.

Planaria grisea Verrill, Rep. Invert. Vineyard Sound, etc., pp. 633 [399], 487 [193], 1873.

Fovia grisea Verrill, Check List Marine Invert., p 13, 1879

Fovia littoralis Verrill, op cit., p. 13, 1879, (? *non* Müller sp.)

PLATE XLI, FIGURES 9, 9*a*, 9*b*.

Body very versatile, in usual extension oblong, widest behind the middle, round or subtruncate at both ends, or with the middle of the front margin a little prominent, sometimes contracting into broad-ovate or cordate forms. The antero-lateral angles of the head are often slightly prominent, subangular or rounded, and very mobile. Mouth nearly central. Principal lateral branches of the stomach mostly bilobed, others simple. The posterior part of the lower surface seems to be capable of being used to some extent as a sucker, for the creature often moves with quick jerks, like a leech, but it is not separated by any constriction from the rest of the body.

Ocelli two, not far apart, black, reniform, with a transparent front lens, each situated in a reniform white patch or spot, widest outwardly.

Color above, yellowish, grayish, reddish, or fulvous brown, or dark brown; margins and lower side paler; over the pharynx and stomach is a long, pale blotch in the middle above, extending in some examples the whole length of the body; the long cylindrical pharynx can sometimes be seen through the integument, especially beneath, extending in partly contracted specimens nearly to the posterior end. Plate XLI, figure 9*b*.

Length 4 to 12^{mm}; breadth 2 to 3^{mm}, in extension.

Ten Pound I., Gloucester, Mass., in tide-pools at low-water, and among eel-grass (*Zostera*) in the harbor, 1878; Casco Bay, Me., at low-water, under stones, 1873, (var. *grisea*); Watch Hill, R. I.,

at low-water mark, April, 1872 (A. E. V.), var. *grisea.* Beverly, Mass. (Girard), var. *Warreni.*

This species is not abundant on our coast. I have taken only a single specimen of a dark green variety (referred doubtfully to this species) at Eastport, Me., and Grand Menan, N. B., during many seasons spent in studying the fauna of that region.

Our species appears to vary widely in color, but I am unable to find other differences sufficient to indicate more than one species. Nevertheless, it may be well to designate the principal color-variations as varieties until better known, especially as they have already received specific names.

Variety, **Warreni** Girard.*

Color red or reddish brown.

Variety, **grisea** Verrill

Planaria grisea Verrill, Invert Vineyard Sd, p 633 [339], 1873

Color grayish, yellowish or greenish above, with a median whitish streak. Pl. XLI, figs. 9–9*b*.

The original description is as follows:—

"Body elongated and usually oblong in extension, often long oval or somewhat elliptical, obtusely pointed or rounded posteriorly; head subtruncate in front, often a little prominent in the middle; the angles are somewhat prominent, but not elongated. Ocelli two, black, each surrounded by a reniform white spot. Color yellowish green or grayish, with a central whitish stripe in the middle of the back, surrounded by darker; head margined with whitish. Length, in extension, 12^{mm}; breadth, 3^{mm}."

Watch Hill, R. I, under stones, between tides (April, 1872).

This species is referred to that of northern Europe with some doubt, owing to our imperfect knowledge of the internal anatomy of both forms. Externally they appear to agree closely.

* I should retain this name with some hesitation for this form, from the original description alone, which is too indefinite to enable one to be certain as to its application to a species of this genus, as now defined. But as Stimpson had Girard's original drawings for examination, and gave a more precise definition to this genus, it must be presumed that *F. Warreni*, the type, conforms to his definition.

There is a peculiar red planarian, on our coast (see pl. XL, fig 9), which agrees well with Girard's description, so far as it goes, but my specimens had no distinct ocelli This is the species referred to *F Warreni* by me in the Report on Invert. of Vineyard Sound, p. 633 [339]. 1873. Additional studies of fresh specimens are essential. in order to identify it.

The synonymy of the European species is still doubtful, for some European authors refer the *Planaria littoralis* Müller to this genus, while others consider it identical with *Procerodes ulvæ* Œrsted sp. As Müller's species is doubtful, I have preferred to adopt a later name, which appears to be applicable to our American form.

Procerodes Girard

Procerodes Girard, Proc Boston Soc Nat Hist, vol. iii, p 251, 1850, Stimpson, Prodromus, p [5] 23, 1857, Diesing, Rev Turbell, Dendrocœlen, pp 491, 520, 1861, Jensen, op cit, p 74

Size small. Body convex, thickened, more or less oblong. Head obtuse, somewhat wider than the neck. Tentacles two, near to, but distinct from, the antero-lateral margins of the head. Eyes two, well developed, situated just behind the tentacles, furnished with a transparent front lens, directed antero-laterally, and a reniform, pigmented retinal portion. Pharynx long, cylindrical. Mouth submedian, or in advance of the middle of the body.

Owing to the dark color and opacity of my specimens, when living, I was unable to observe the structure of the reproductive organs, nor did I ascertain positively whether the intestinal branches were chiefly simple or branched, but they appeared to be forked, or bilobed, in many cases, at least. My specimens are all mounted in balsam, so that sections cannot well be made, at present. The mounted specimens are very dark.

Procerodes ulvæ (Œrsted) Stimp

Planaria ulvæ Œrsted, Kroyer's Naturh. Tidssk, iv, p 550, 1844, Diesing, Syst., vol i, p. 205, 1850

Procerodes Wheatlandii Girard, Proc. Boston Soc. Nat Hist., iii, p. 251, 1851; Stimpson, Prod, p. 6, 1857; Diesing, Revis Turbell., Abtheil, Dendroc, p. 520, 1861; Verrill, Invert Vineyard Sd, etc, p 633 [339], 1873

Procerodes ulvæ Stimpson, Prod, p 6, 1857, Diesing, Revis Turbell, p. 521; Jensen, Turbell Lit. Norvegiæ, p 74, 1878

Planaria frequens Leidy. Marine Invert Fauna of Rhode I. and New Jersey, p 11, 1855, in Journ. Philad Acad. Nat. Sci., ser 2, vol. iii, p. 14.

Procerodes frequens Stimp, op cit., p 6, Diesing, Rev. Turbell., p. 521; Verrill, op. cit., p 325 [31].

PLATE XLI, FIGURE 10, PLATE XLII, FIGURES 11, 11*a*.

Body, in ordinary extension, oblong-oval, rather wider posteriorly than anteriorly, broadly rounded at the posterior end, convex dorsally and flattened beneath; the neck narrows decidedly in normal extension. Head distinctly wider than the neck, rounded in front.

Tentacles whitish, when extended a little elongated and tapered to a point, but capable of complete retraction and usually not visible in preserved specimens, though their position may be indicated by small white spots; they are situated near the antero-lateral margins of the head, but not on the margins. Eyes rather large, black, but not easily seen, owing to the dark color of the integument.* Mouth submedian.

Pharynx, as retracted in mounted specimens, long, rather narrow, cylindrical, equal to a third, or even nearly half the length of the body, its posterior end reaching back to about the posterior fourth of the body.

Color, above, dark smoky brown or blackish, often with a more or less distinct stripe of light gray or yellowish white along each side of the back, sometimes mottled with darker and lighter brown; beneath paler; tentacles and margins of head whitish.

Length 4 to 6^{mm}; breadth 1 to 1.5^{mm}.

New Haven to Bay of Fundy. Point Judith, R. I., (Leidy); Manchester, Mass., (Girard). I have collected it at New Haven, Conn., Newport, R. I., Wood's Holl, Mass., Casco Bay, Me., etc. It is found also on the northern coasts of Europe. Found near low-water mark under stones, and in tide-pools, among algæ.

This species is active in its habits. It has a singular resemblance to some of the small land slugs in form and mode of progression. Its egg-capsules are unknown to me.

PART II.—*Acœla.*

The accelous planarians of our coast have, hitherto, received but little attention. Besides the few species noticed below, I have observed several others, but not with sufficient care to enable me to give satisfactory diagnoses. Some of the species are very common among algæ and eel-grass in shallow harbors.

The Acœla are remarkable for the absence of any distinct membrane lining the digestive cavity, so that no distinction can be made between the body-cavity and digestive cavity. This cavity is lined with a loose cellular parenchyma and has an indeterminate outline; it is often very large and usually filled with large numbers of small crustaceans, diatoms, and various other organisms.

The mouth is often at, or near, the anterior end of the body, but

* The eyes are not distinctly shown in the figure (pl. XLI, fig. 10), owing to the dark shading.

it may be near the middle of the ventral side, or even behind the middle. It is often large and is sometimes simple, but more frequently it is surrounded by a slightly developed muscular ring or collar; more rarely there is a rudimentary pharynx. The integument is generally filled with clusters of rhabdites. There is often a peculiar glandular frontal organ opening at the anterior end.

The brain, longitudinal nervous trunks, and nervous branches are present, but not so well-defined as in the previous groups. A pair of ocelli may be present, but are oftener absent. A median otocyst is almost always present. Posterior tentacle-like organs or cirri are sometimes present

The reproductive organs are variable in structure and position. Sometimes there is but a single genital pore, but usually there are two median ones, posteriorly situated, the male orifice being behind the female. The ovaries are usually lateral and paired; special yolk-glands are not developed. A bursa seminalis or spermatheca may be present, or absent; sometimes there are two. The testes are folicular and imbedded in the parenchyma. The penis may be simple or armed; a seminal vesicle is usually present. Eggs are usually enclosed in capsules.

The external form is exceedingly varied. Many species are flat, broad-elliptical or ovate; others are long and narrow; some are nearly terete; others are angular in outline. Some species (*Convoluta*) habitually curl the sides of the body inward and downward, so that they appear narrower than they really are. The size is generally small, the colors often bright.

Family, Aphanostomidæ Graff, Monog.

Body usually more or less flattened, elliptical, ovate, or cordate, long or short, frequently with the sides curved downward. Mouth ventral, behind the otocyst, often median or submedian. Pharynx rudimentary or wanting. Otocyst present. Ocelli sometimes two, often absent. Genital orifices separate. Penis simple, unarmed. Bursa seminalis well-developed, with one, two, or several tubular outlets.

Aphanostoma Œrsted.

Kroyer's Naturhist. Tidssk., ser 2, vol 1, p. 417, 1845; Carus, Fauna Med., p. 139, 1884; Graff, Monog., p 220; Graff, Turbell. Acœla, pp. 55, 59, 1891
Aphanostomum Jensen, Turbell. Lit. Norvegiæ, p. 22, 1878.

Body more or less flattened, oblong, ovate, or elliptical; usually narrowed posteriorly. Mouth circular, before or near the middle.

A rudimentary pharynx. Otocyst single, near the anterior end. Otolith usually well developed. No ocelli. Frontal glandular organs present.

Genital apertures, posterior; the male behind the female. Spermarian folicles numerous, lateral. Openings of the *bursa seminalis* without chitinous parts. Ovaries paired, lateral.

Aphanostoma diversicolor Œrsted.

Kroyer's Naturhist Tidssk, ser 2, vol i, p 417, 1845, Carus, op. cit., p 139; Graff, Monogr, p. 220, Graff, Turbell Acœla, p 59, pl 5, fig 4, 1891, section.

Aphanostomum diversicolor Jensen, Turbell ad Lit Norvegiæ, p. 26, pl. I, figs. 12 to 21, 1878, anatomy

PLATE XLII, FIGURE 8

Body very changeable, in extension usually long-oval or elliptical, obtuse anteriorly, or tapering to both ends, but most so posteriorly; only a little depressed; in contraction short-ovate and thick.

Color variable, generally with a sulphur-yellow spot on the anterior end and another on the back; a large spot of bluish or violaceous usually covers more or less of the back, and is sometimes divided posteriorly by a V-shaped white line; lateral borders whitish. Mouth subcentral beneath. A cluster of frontal glands is connected with a pore at the anterior end of the body. Otocyst small, much obscured by the pigment, gibbous, situated at about the anterior eighth.

Length, in extension, 1·5 to 2^{mm}; breadth 0·25 to $0·35^{mm}$.

Newport, R. I., July 29, 1880, among algæ at low-water mark. It occurs on the coasts of Norway and Great Britain, and in the Mediterranean at Naples, Trieste, etc.

Aphanostoma aurantiacum sp. nov.

PLATE XLII, FIGURES 10, 10*a*

Body long-ovate in extension, depressed, broadest in front of the middle, usually bluntly rounded anteriorly, but very soft and changeable. Otocyst rather large, conspicuous, situated at about the anterior eighth, gibbous, containing an inverted cup-shaped or bell-shaped otolith, situated at the anterior side of the nearly circular and transparent vesicle. The otolith is almost continually in motion, while living. Ground-color light ocher-yellow, everywhere thickly covered with small, distinct spots or specks of bright orange-red, thus giving the whole surface an orange-yellow color, paler towards the margins. Reproductive organs are unknown.

Length about $1{\cdot}5^{mm}$; breadth $0{\cdot}35$ to $0{\cdot}50^{mm}$.

Newport, R. I., at low-water mark, among algæ, July 29, 1880.

This species is only provisionally referred to the genus *Aphanostoma*, for its internal anatomy was not studied. The specimens were lost.

Aphanostoma olivaceum sp nov.

PLATE XLII, FIGURE 9

Body ovate, broadest anteriorly, rather thick, convex. Otocyst conspicuous, at about the anterior eighth. Mouth rather behind the middle; digestive cavity large, behind the middle; in the example figure it contained an amphipod crustacean.

The ovaries are large, lateral; posteriorly, the oviducts are filled with two or three rows of large ova, which are dark green in color. The female orifice is about midway between the posterior border of the digestive cavity and the male orifice. The latter is near the posterior margin, in the center of a pale spot. It is flanked on each side by two small vesicles (probably seminal vesicles); two larger saccular organs (perhaps the posterior part of *vasa deferentia*) run forward and diverge, but their nature was not certainly ascertained' owing to the dark color of the integument. The form and structure of the penis and spermatheca were not observed, for the same reason

Color dark olive-green, or brownish green.

Length 2^{mm}; breadth about $1{\cdot}5^{mm}$.

Provincetown, Mass., at low-water mark, among filamentous algæ, Aug. 14, 1879.

This species is referred to *Aphanostoma* only provisionally, for its reproductive organs are imperfectly known. It has considerable resemblance to certain species of *Mecynostoma*.

Polychœrus Mark.

Festschrift für Leuckart, p. 298, Oct., 1892.

Body flattened, changeable in outline, usually cordate or ovate, narrowest anteriorly, emarginate or bilobed posteriorly, with one to five slender, contractile caudal cirri. The lateral margins are usually not inflexed. Mouth central or nearly so, with simple muscular margins. No proper pharynx. Digestive cavity large, separated posteriorly from the genital area by tissues more dense than those of other parts.

Otocyst small, round, sometimes indistinct or wanting; otolith cup-shaped.

Brain distinctly bilobed; each ganglion is somewhat stellate in form, and gives off three main nerves: anterior, lateral, and poste-

rior. The superficial nerves are extensively anastomosed, so as to form a network of irregular meshes.

Ovaries large, on each side of the digestive cavity; oviducts large, often much distended posteriorly by clusters of large mature ova. Spermarian folicles numerous, situated on each side of, and often extending nearly or quite around, the digestive cavity. *Vasa deferentia* large, more or less saccular posteriorly, when distended with their contents, and connected with a circular seminal vesicle surrounding the base of the penis.

The penis is unarmed and in contraction ovoid or conical, but rather long, tapered, and usually somewhat curved when fully extended. (See plate XLIV, figs. 6, 8, 9).

The male orifice is near the posterior margin, in front of the median caudal cirrus.

The female orifice is situated a little farther forward and communicates with a simple tubular vagina, which runs up dorsally beneath the saccular spermatheca.

Spermatheca or *bursa seminalis* is large, complex, reniform or cordate, with numerous chitinous outlet-tubes scattered over the surface.

Rhabdites and pigment-corpuscles are contained in the integument.

Polychœrus caudatus Mark

Mark, op cit., pp 298–309, pl XXI, figs 1–22, anatomy.

PLATE XLI, FIGURES 11, 11*a*: PLATE XLIV, FIGURES 6 TO 10

Body depressed, flat or concave beneath, somewhat convex above, and often gibbous or swollen dorsally, when filled with ova; in extension varying from broad cordate to narrow-ovate, according to the state of contraction; front end bluntly pointed or evenly rounded; sides often nearly parallel; posterior end usually deeply emarginate, with a broad median notch and rounded lobes each side of it; margin thin, sometimes inflexed, especially when swimming.

Caudal cirri one to five. In adult examples there are generally three slender, pale, translucent caudal cirri, one of which is median, while the others, which are usually a little smaller, arise from near the inner border of the posterior lobes. Sometimes, in large specimens, another smaller pair is developed external to the latter, on the posterior lobes (pl. XLIV, fig. 6). In young specimens the median cirrus appears first. The cirri all arise at a slight distance from the margin, on the dorsal side. Each one can be retracted into a small, basal, bulb-like, muscular, invaginated cavity of the

integument. The caudal cirri are often lost by injuries, but are quickly reproduced.

The otocyst is small, circular, situated well forward at about the anterior fourth; otolith cup-shaped. In some specimens the otocyst appears to be rudimentary or wanting; in many it can scarcely be seen while living, owing to its small size and the great amount of pigment in the integument; in others it is easily visible.

Mouth central or subcentral, simple, circular or transversely elliptical, highly dilatable, surrounded by circular muscular fibers. The digestive cavity is capacious, more or less irregular in outline. It is usually filled with various Entomostraca and other small crustaceans.

The genital openings are small, round, near together, and usually not very distinct. The male orifice is a little in advance of the base of the median caudal cirrus. The penis, as seen from beneath and foreshortened in mounted specimens, is usually ovoid or conical; when protruded it is rather elongated, cylindrical or tapered, often curved, with a conical tip. Its base is surrounded by a circular seminal vesicle (pl. XLIV, figs. 6–10, *r*) which receives the *vasa deferentia* (*d*) on the right and left sides. The latter are voluminous, more or less saccular and contorted posteriorly, when filled with their contents.

The spermarian folicles (*t*) are small, numerous, pyriform, and extend along each side above and partly external to the ovaries and oviducts, as far as the anterior margin of the digestive cavity, where they converge and nearly or quite blend at the median line, when fully developed.

The oviducts are large and saccular and lie close to the digestive cavity, on each side; posteriorly they are often much swollen by large clusters of relatively large mature ova, of which there are often six to ten, arranged in two or three rows, in each cluster; those farthest back often crowd against and more or less distort and conceal the spermatheca and other organs, and make that part of the body gibbous externally.

The spermatheca (figs. 6, 7, 8, *s*) is large, glandular and saccular dorsally, variable in shape, but when least crowded it is generally broad-cordate or reniform; the emargination of the posterior side includes the female orifice and vagina. Its ventral surface is covered with small brownish, chitinous, conical outlet-tubes or "mouth-pieces," differing in size and varying in number in different specimens from six or eight up to thirty or forty; most frequently twelve to fifteen fully developed ones and several smaller

ones can be seen. Each of these is surrounded at base by a circle of glandular cells.*

In small specimens the male organs are often well developed before the female organs appear.

According to Professor Mark, the spermatozoa are long and filiform, thickest in advance of the middle, with a very slender anterior portion, more active and more attenuated than the posterior portion.

Color usually brick-red or dark orange-red, sometimes pale red, with a central paler spot over the digestive cavity, and usually with a circular or horse-shoe-shaped region of darker brownish red color over the ovaries, and almost entirely surrounding the digestive region, interrupted posteriorly; margins pale; caudal cirri translucent, whitish; ventral surface yellowish.

The orange color, according to Professor Mark's observations, is due to clusters of two kinds of minute pigment-corpuscles. Of these, the most numerous are greenish yellow; the others, which are smaller and less numerous, are purplish. The pale median patch is caused by whitish, mostly rod-like, corpuscles. Clusters of cigar-shaped rhabdites are also scattered in the integument.

Length 3 to 4^{mm}; breadth 1·5 to 2^{mm}.

Common from Great Egg Harbor, N. J. to Casco Bay, Me.; especially in sheltered harbors, adhering to eel-grass (*Zostera*) and creeping over the vegetable debris, shells, etc., on the bottom in shallow water, where it is often extremely abundant.

I have taken it in large numbers, especially in New Haven Harbor, 1865 to 1870; Noank, Conn., 1874; Newport, R. I., 1880; Wood's Holl, Mass., 1871, 1875, 1881 to 1887. At Quahog Bay, Me., in 1873, I found it in small numbers, but have not observed it farther north.

I have been familiar with this species for many years, and have had several drawings and descriptions of it made as early as 1874 and 1875, but had put them aside with those of various other Turbellaria.† Not knowing that Professor Mark had worked upon

* Professor Mark (op. cit.) describes some of these "mouth-pieces," observed by him, as filled with the filiform spermatozoa, with clusters of them hanging from the basal portion He also observed large masses of spermatozoa in the dorsal cavities of the spermatheca, with which the "mouth-pieces" communicate The vagina terminates in proximity to the dorsal cavities of the spermatheca

† In the summer of 1874, while in charge of the invertebrate zoology of the U S. Fish Com, at Noank, Conn, I had the pleasure of studying this species in company with the late Professor Joseph Leidy, who was much interested in its anatomy For that reason in my MSS. notes I had named it in honor of Professor Leidy.

it, and before his excellent paper had been published, I had resumed the study of the species and prepared descriptions of the genus and species for this article. Having received Professor Mark's paper, just as the last pages of my own were going to press, I have been able to add several additional anatomical facts of importance, which I had not personally observed. Professor Mark, in his paper, moreover, describes in detail the nervous system, and also numerous additional features not here referred to, or only briefly mentioned.

My own conclusions, in regard to the essential structure and affinities of the genus, were perfectly in accord with those of Professor Mark The few additional details that I have given in the preceding description are due to the larger series that I have had for study, or to their different modes of preservation.

Professor Mark informs me that he has found the egg-capsules of this species in abundance on dead shells and stones in the harbor of Wood's Holl, Mass. They are circular, flat on the lower side, by which they are attached, and a little convex on the upper side, with thin margins. I have not met with them myself. In several instances I have seen living young individuals in the interior of the body of adults, but it is quite possible that they had been swallowed as food with other small prey. The mode of depositing the egg-capsules is unknown. There seems to be no special opening adapted to that purpose. Possibly they escape from the mouth. The specimen figured on pl. XLI, fig. 11*a*, appears to contain egg-capsules in process of formation, but as the specimen was not preserved, this cannot now be confirmed.

Doubtful Species.

Typhlocolax acutus Stimpson, Prod, p 3, 1857

Typhlolepta acuta Girard, in Stimpson, Invert Grand Manan, p 27, 1853, Diesing, Rev Turbell., p 523, 1861

"Body depressed, ovoid, elongated, posteriorly rounded; anterior extremity terminating in an acute point; mouth underneath, and situated at about the middle of the body. Length about a sixteenth of an inch. Ground color pale, with reddish confluent blotches above. Found in considerable numbers creeping over the surface of *Chirodota lævis.*"

Dr. Stimpson (Prodromus, p. 3) referred this genus and species to the Digonopora, but its internal structure was not known to him. It is more probable that it belongs to the Acœla or Rhabdocœla. I have not observed it myself, although I have collected numerous specimens of the holothurian, on which it is said to be parasitic, in the original locality.

INDEX TO THE GENERA AND SPECIES.

EXPLANATION OF PLATES.

PLATE XL.

Figure 1.—*Imogine oculifera* Girard. p. 475. Dorsal view of a young living specimen with dendritic, rose-colored makings; ×20. Wood's Holl, Mass

Figure 2.—*Eustylochus ellipticus* (Girard) V., p 467. Dorsal view of a living specimen, much compressed; ×6. Savin Rock, near New Haven, Conn., 1868.

Figure 3.—*Stylochus zebra* V, p. 463. Dorsal view of a living specimen; ×4 Wood's Holl, Mass., Sept. 23, 1882.

Figure 4.—*Planocera nebulosa* Girard, p. 472. Dorsal view of a living specimen, ×5. New Haven, Conn., 1870

Figure 5—*Leptoplana ellipsoides* Girard, p. 483. Dorsal view of a living specimen; ×5. Eastport, Me, 1870, at low-water. Color orange-brown with irregular spots of dark brown and small specks of white. (The clusters of ocelli occupy unusual positions, owing to a peculiar state of contraction).

Figure 6—*Leptoplana ellipsoides*. Dorsal view of a large example, from life, in the act of creeping; ×4 Eastport, Me., August 10, 1872.

Figure 7.—*Discocelis mutabilis* V. (?), p. 493. Dorsal view of a young living specimen; much enlarged Surface, Wood's Holl, Mass., August 16, 1882. Transparent, with yellow spots around the margin.

Figure 8.—*Leptoplana angusta* V., p. 485. Dorsal view of a young living example, ×10. Provincetown, Mass., from the bottom of a whaler.

Figure 9.—*Fovia affinis* (?). See foot-note, p. 505. Dorsal view; ×6. Noank, Conn., in harbor, July 16, 1874.

Figure 10.—*Bdelloura candida* Girard, p. 499. Ventral view (*a*), from life: dorsal view (*b*); about natural size; 10*b*, the same, posterior sucker; ×4.

Figures 1, 3, 6, 7, 10 were drawn from life by J. H. Emerton; figure 9 by J. H. Blake; the rest by the author

PLATE XLI.

Figure 1.—*Eustylochus ellipticus* (Girard) V., p. 467. Dorsal view of a living specimen; ×4. 1*a*, the same, one of the tentacles; more enlarged. Newport, R. I., on piles of railroad bridge. August 20, 1880.

Figure 2.—*Eurylepta maculosa* V., p. 495. Dorsal view of a living specimen; ×5. Wood's Holl, Mass., on piles, July 15, 1881.

Figure 3.—The same. Dorsal view of a living specimen; ×5. Naushon Island, at low-water mark, August 20, 1887.

Figure 4.—*Trigonoporus dendriticus* V., p. 491. Dorsal view of a living specimen; ×4. Sta. 317, off Cape Cod, 25 fath., 1879. Color light pink with a pale central area. (The clusters of ocelli are too angular and definite.)

Figure 5.—*Trigonoporus folium* V., p. 487. Dorsal view from life; ×2. Fig. 5*a*, the same, ventral view. Sta. 784, off Point Judith, R. I., in 20 fath., 1880.

Figure 6.—*Trigonoporus folium* V, p. 487. Dorsal view of a living specimen; × 5. Sta. 134, off Cape Ann, Mass., in 26 fath., July 23, 1878. Color yellowish brown with the gastric region and margins pale; ganglions and nerves pink.

Figure 7.—*Leptoplana variabilis* (Girard). No. 20, p. 480. Dorsal view, from life; × 5. Sta. 156, off Gloucester, Mass., 42 fath, Aug. 15, 1878. Color yellowish brown with pale margins and central stripe. The clusters of cerebral ocelli are too long and too divergent.

Figure 8.—*Bdelloura candida* Girard, p. 499. Dorsal view of a living specimen slightly compressed between glasses, and seen by transmitted light; × 3

Figure 9.—*Fovia affinis* (Œrs.) Stimp. (var. *grisea* V.), p. 504. Dorsal view of a living specimen; × 6. Fig. 9*a*, the same specimen strongly contracted while living; × 6. Fig. 9*b*, the same; dark-brown variety. Ventral view of a living specimen, seen by transmitted light; × 3. Gloucester, Mass, on eel-grass (*Zostera*), 1878.

Figure 10.—*Procerodes ulvæ* (Œrs.) Stimp., p. 506. Dorsal view of a living specimen; × 8. Casco Bay, at low-water mark, 1873. The ocelli are not shown, owing to the dark shading.

Figure 11.—*Polychœrus caudatus* Mark, p. 511. Dorsal view of a living specimen; × 20. Noank, Conn., July 30, 1874. The caudal cirri should have been left without color.

Figure 11*a*.—The same. Another individual seen as a transparent object, slightly compressed between glasses. Wood's Holl, Mass., 1881. The bilobed body, covering the region of the spermatheca, was probably an egg-capsule (or two of them) in process of formation (see p. 514).

Figures 3 and 11 were drawn by J. H. Blake; 4, 6, 7, 8, 9*b* by the author; the rest by J. H. Emerton.

PLATE XLII.

Figure 1.—*Eustylochus ellipticus* (Girard) V., p. 466. Dorsal view of a living specimen; × 6. New Haven Harbor, Oct., 1892.

Figure 1*a*.—The same specimen. Ventral view; × 6; *b*, one of the tentacles; *c*, brain; *f*, pharynx; *m*, mouth; *d*, vas deferens; *r*, seminal vesicle; *p*, penis; *p′*, penis-bulb and granular gland; ♂, male orifice; ♀, female orifice; *s*, spermatheca; *s′*, duct of the same; *v*, vagina; *u*, large oviduct or uterine sac; *z*, orifice of the median nephridial tube (*z′*).

Figure 1*b*.—The same. Male genital organs of a young mounted specimen; much enlarged; *d*, *d*, vasa deferentia; *r*, seminal vesicle; *p*, penis; *p′*, penis-bulb and granular gland. New Haven Harbor, Oct., 1892.

Figure 2.—*Stylochus zebra* V., p 463. Ventral view of a living specimen; × 4; *f*, pharynx; *m*, mouth; *d*, vas deferens; ♂, male orifice; ♀, female orifice; *w*, shell-glands. Off New Haven.

Figure 2*a*.—The same. Dorsal view of the head and anterior portion of another specimen from the same locality, from life; × 4.

Figure 3.—*Planocera nebulosa* Girard, p. 473. Genital organs of a young specimen; much enlarged. New Haven Harbor, Oct., 1892. *d*, vas deferens; *r*, seminal vesicle; *r′*, its duct; *p*, penis and penis-sheath; *p′*, penis-bulb and granular gland; ♂, male orifice; ♀, female orifice; *v*, vagina; *s*, spermatheca.

Figure 4.—*Trigonoporus dendriticus* V., p. 491. Ventral view of a specimen mounted in balsam; × 6. Station 317, off Cape Cod, 1879.

Figure 4*a*.—The same specimen. Brain and clusters of ocelli; ×25; *c*, brain; *e*, cerebral ocelli; *e'*, dorsal ocelli; *g*, *g*, anterior branches of the stomach. Fig. 4*b*, cerebral ocelli of the same specimen, ×25.

Figure 5.—*Trigonoporus folium* V., p. 487. Ventral view of a specimen mounted in balsam; ×6. Eastport, Me., 1870 Fig 5*a*, ocelli of the left side of the same specimen, ×20; *e*, cerebral cluster; *e'*, dorsal cluster. Fig. 5*b*, ocelli of the right side of the same specimen; ×25; *e*, cerebral cluster; *e'* dorsal cluster.

Figure 6—*Discocelis mutabilis* V., p. 493. Dorsal view of the original, type-specimen mounted in balsam; ×8 Thimble Islands, 1872.

Figure 6*a*.—The same specimen. Clusters of ocelli; ×25; *e*, cerebral, and *e'*, dorsal clusters of ocelli.

Figure 7.—*Discocelis mutabilis* V. (?), young, p. 494 Dorsal and cerebral ocelli of a mounted specimen; ×25. Wood's Holl, Mass., 1882.

Figure 8.—*Aphanostoma diversicolor* (Œrst.), p 509 Dorsal view of a living specimen; ×20. Newport, R I, 1880

Figure 9.—*Aphanostoma olivaceum* V., p. 510. Ventral view of a living specimen, ×12; *ot*, otocyst; *g*, digestive cavity containing an amphipod crustacean; *u*, large oviduct containing ripe ova; ♀, female orifice, ♂, male orifice and penis

Figure 10.—*Aphanostoma aurantiacum* V., p. 509 Dorsal view of a living specimen; ×20.

Figure 10*a*.—The same specimen Otocyst; more enlarged

Figure 11.—*Procerodes ulvæ* (Œrst), p. 506. Dorsal view of head of a living specimen; ×12 Casco Bay, Me, 1873.

Figure 11*a*.—The same. Dorsal view of another specimen mounted in balsam; ×8, *o*, ovaries; *f*, pharynx; *p*, penis; ♀ ♂, common genital orifice. (In this figure the number and form of the gastric branches are partly diagramatic, for many of them could be seen only indistinctly).

Figures 1, 1*a*, 2, 2*a*, 4, 4*a*, 5, 6 were drawn from nature by A. H. Verrill, 8 and 10 were drawn from life by J. H. Emerton; the rest are camera-lucida drawings by the author.

PLATE XLIII.

Figure 1.—*Leptoplana virilis* V, p. 478. Ventral view of the type-specimen, stained and mounted in balsam; ×6 Sta 307, Off Cape Cod, Mass., 31 fath, 1879

Figure 1*a*.—The same specimen. Posterior portion, ventral view; ×15; *f*, pharynx; *r*, seminal vesicle; *k*, granular gland and penis-bulb; *p*, penis; *q*, penis-sheath; *t*, *t*, spermarian folicles or testes: ♂, male orifice; ♀, female orifice; *o*, *o*, *o*, ovarian folicles; *v*, ventral portion of vagina; *v'*, dorsal portion of the same; *s*, spermatheca; *s'*, anterior portion of the same and its connection with the vagina; *w*, shell-glands; *u*, one of the uterine sacs.

Figure 2.—*Leptoplana variabilis* (Girard) V., young, p. 480. Dorsal view of a mounted specimen; ×8. Gloucester, Mass., in tide-pool, 1878.

Figure 3.—*Leptoplana variabilis* (Girard) V. No. 20. Ventral view of a mounted specimen; ×6. Sta. 156, off Cape Ann, Mass., 42 fath., 1878.

Figure 3*a*.—The same specimen. Genital organs, dorsal view; ×15; *d*, *d*, vasa deferentia; *k*, granular gland; *p*, penis, *q*, penis-sheath; ♀, female orifice; *v*, ventral portion of vagina; *v'*, dorsal portion of the same; *s*, spermatheca; *s'*, anterior division of the same and its connection with the vagina; *w*,,*w*, shell-glands; *u*, *u*, large oviducts or uterine sacs; *u'*, duct of the same leading to the vagina; *x*, orifice of the nephridial duct (?); *g'*, *g'*, posterior gastric branches.

Figure 3*b*.—The same specimen. Ocelli and brain; × 25; *c*, brain; *e*, cerebral ocelli; *e'*, dorsal ocelli.

Figure 4.—*Leptoplana ellipsoides* Girard, p. 483. Ocelli; × 25; *e*, cerebral, and *e'*, dorsal clusters. Eastport, Me., 1872.

Figure 4*a*.—The same. Dorsal view of the genital organs; × 15. The lettering is the same as that of 3*a*. Figure 4*b*.—The same parts; ventral view.

Figure 5.—*Trigonoporus dendriticus* V., p. 491. Type-specimen. Sta. 317. Ventral view of the genital organs; × 25; ♂, male orifice; *p*, penis; *p'*, penis-bulb; *q*, penis-sheath; *k*, granular gland; ♀, anterior female orifice; ♀', posterior female orifice; *w*, shell-glands.

Figure 6.—*Polychœrus caudatus* Mark, p. 512. Ventral view of a mounted specimen; × 15. Wood's Holl, Mass., 1881. This specimen is noteworthy for having five caudal cirri The digestive cavity contains numerous small crustaceans.

Figure 7.—The same. Ventral view of a mounted specimen having three caudal cirri; × 15: ♀, female orifice; *s*, spermatheca; *o*, one of the ovaries; *t*, spermarian folicles or testes; *p*, retracted penis and male orifice.

Figure 8.—The same. Ventral view of the genital organs of a mature specimen; × 30; *d*, *d*, vasa deferentia; *r*, seminal vesicle; *p*, penis exserted; ♀, female orifice; *s*, spermatheca or bursa seminalis; *o*, cluster of mature eggs.

Figure 9.—The same. Male genital organs of another specimen with the penis (*p*) fully exserted; *r*, seminal vesicle; × 30.

Figure 10.—The same, another specimen. A partially profile view of the genital organs; × 30; ♀, female orifice; *v*, vagina: *p*, penis partly protruded; *d*, *d*, vasa deferentia; *r*, seminal vesicle.

Figure 11.—*Bdelloura candida* Girard, p. 499. Ventral view of a specimen containing a nearly mature egg-capsule; × 6; *c*, brain and ocelli; *h*, longitudinal muscles of the sucker; *n*, one of the longitudinal nerve-trunks; *n'*, frontal nerves; *g*, anterior division of the stomach; *f*, pharynx; *o*, *o*, ovaries; *ca*. egg-capsules; *u*, uterine sac or accessory gland.

The large chitinous egg-capsule occupies the entire thickness of the body, no organs appearing over its central part, on either side, except the thin, stretched integument; its front edge lies above the end of the pharynx, and the *vasa deferentia* run above its lateral borders. How it is expelled is not known.

Figures 1, 1*a*, 2, 3, 3*a*, and 11 were drawn from nature by A. H. Verrill; the rest by the author.

PLATE XLIV.

Figure 1.—*Stylochus frontalis* V., p. 465. Ocelli and tentacles of the type-specimen, mounted in balsam; × 30; *b*, *b*, tentacles retracted: *e*, *e*, cerebral clusters; *e'*, *e'*, dorsal clusters at base of tentacles; *e"*, *e"*, scattered frontal ocelli.

Figure 2.—*Leptoplana angusta* V., p. 485. Ventral view of one of the type-specimens, mounted in balsam; × 12; *c*, brain; *f*, pharynx; *m*, mouth; *t*, *t*, spermarian folicles; *d*, vas deferens; *p*, penis and penis-sheath; *v*, vagina and shell-glands; *s*, spermatheca; ♀, female orifice; *u*, uterine sac filled with mature ova.

Figure 2*a*.—The same. Brain and ocelli; × 30; *c*, brain; *e*, cerebral, and, *e'* dorsal clusters.

Figure 3.—The same. Reproductive organs of another mounted specimen; × 20; *p*, penis; *q*, penis-bulb and sheath; *v*, female orifice and ventral portion of vagina; *v'*, dorsal portion of vagina: *u*, *u*, large oviducts or uterine sacs filled with mature ova.

Figures 4, 4*a*.—*Trigonoporus folium* V., p 487. Original type-specimen mounted in balsam. 4, ventral view of the genital organs, × 15; ♂, male orifice; *p*, penis; *k*, penis-bulb and granular gland; ♀, anterior female orifice in a cup-like depression; *v*, vagina mutilated; *w*, *w*, shell-glands. 4*a*, dorsal view of the same parts, with the same lettering, and *p'*, penis-sheath; *v'*, dorsal portion of vagina; ♀', posterior female orifice.

Figure 4*b*.—The same specimen; *e*, cerebral ocelli; *e'*, dorsal ocelli; × 30

Figure 4*c*.—The same specimen. Part of front margin and marginal ocelli; × 30.

Figure 4*d*.—The same specimen. Mouth and retracted pharynx, ventral view; × 10.

Figure 5*b*.—The same. Brain and ocelli of a specimen from sta. 134, 1878. Ventral view; × 50; *c*, *c*, cerebral ganglions; *e*, cerebral ocelli; *e'* dorsal ocelli; *n*, *n*, large frontal nerves; *g*, median anterior gastric branch.

Figure 6.—The same. Genital organs of a specimen from sta 301 Ventral view, × 30; ♂, male orifice; *p*, penis; *p'*, interior of penis-bulb, *q*, penis-sheath; *k*, granular gland; ♀, anterior female orifice, ♀', posterior female orifice, *v*, ventral part of vagina; *v*, dorsal part of vagina; *w*, shell-glands; *u*, supposed orifice of nephridial duct.

Figure 7.—The same. Genital organs of a specimen from sta. 182, 1878 Ventral view; × 30. Lettering is the same as in fig. 6.

Figure 8.—*Bdelloura candida* Girard, p 499. A specimen stained with borax-carmine and picric acid and mounted in balsam. New Haven, Oct, 1892. Ventral view; × 10; A, posterior sucker; *c*, *c*, two cerebral ganglions of the brain, and the ocelli; *c'*, main frontal nerves (five pairs are shown, by stippled lines, with a few of their branches); *n*, one of the great longitudinal nerve-trunks; *n'*, posterior commissure uniting the nerve-trunks, from this part large numbers of branches diverge to the borders of the posterior sucker; *nn* one of the several serial transverse commissures uniting the nerve-trunks; *n'*, marginal nerve and exterior branchlets; *f*, pharynx, retracted; *f'*, its open end; *g*, anterior median division of the stomach; *g'*, one of the two main posterior divisions of the stomach; *g"*, one of the transverse lateral gastric branches (The stomach and its branches are left unshaded for greater clearness; they are usually more deeply colored than the other organs); *o*, left ovary; *o'*, its duct: *y*, vitellaria or yolk-glands; *x*, left accessory female gland or "uterine sac" and its convoluted duct, going to the female genital organs; *p*, penis and penis-sheath; ♀ ♂, common genital orifice; *t*, *t*, testes or spermarian folicles.

Figure 8*a*.—The same. Ventral view of the posterior part of a living specimen compressed between glasses; × 20. The gastric branches are distended by the pressure and the nervous system is omitted. The lettering is the same as in fig. 8, with the following additions; *d*, vas deferens of the right side; *r*, seminal vesicle; *v*, vagina.

Figure 8*b*.—The same. Side and profile views of an egg-capsule that was attached by both ends; × 8

Figures 2, 3, 4, 4*a*, 8, 8*a*, 8*b* were drawn from nature by A. H. Verrill; the rest by the author.

INDEX.

ERRATA.

Page 166, fifth line from bottom, for melancholia, read melancholica

Page 170, eleventh line from bottom, for C. crocata, read G. crocata

Page 170, seventh line from bottom, for C. bivittata, read G. bivittata ; also, p 171, sixth and sixteenth lines from top and ninth line from bottom.

Page 191, ninth line from top, for Cælotes, read Cœlotes.

Page 283, fourth line from bottom, for cius, read Icius

Page 317, sixth line from top, for A. flammea nigrescens, read S. flammea nigrescens.

Page 337, fourteenth line from bottom, for schlateri, read sclateri.

Page 442, second line from top, for Schizonertina, read Schizonemertina.

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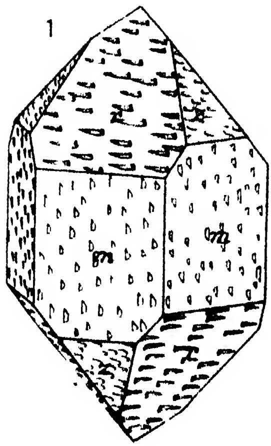

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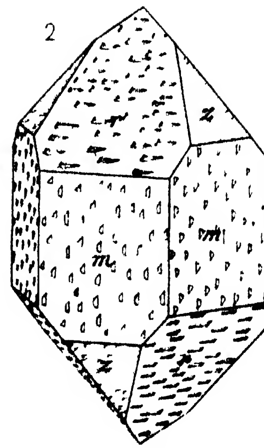

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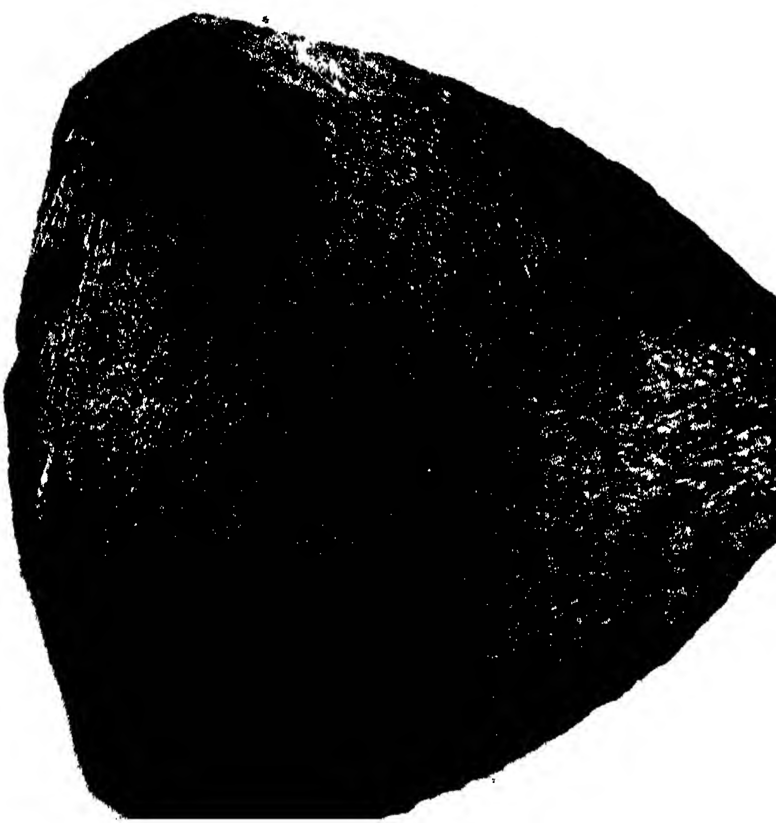

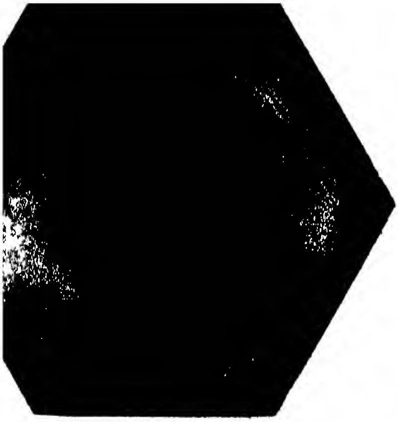

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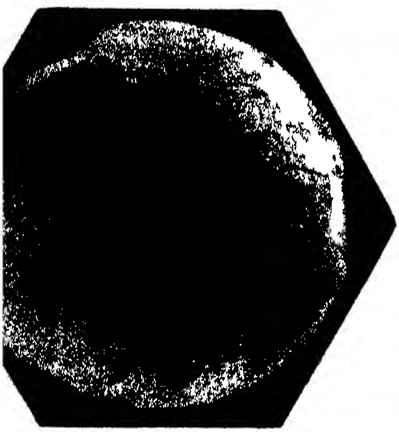

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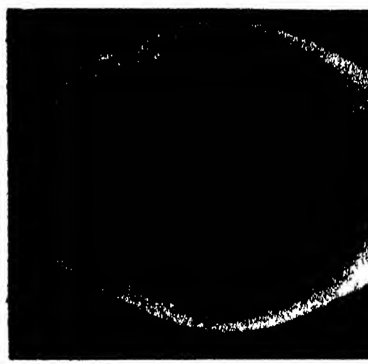

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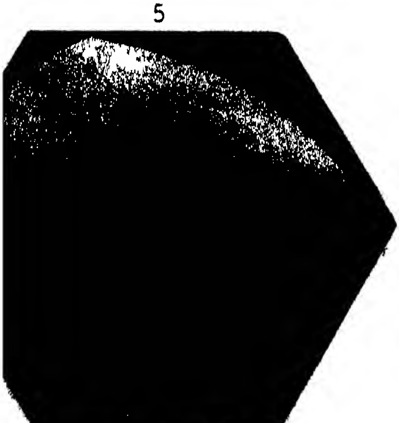

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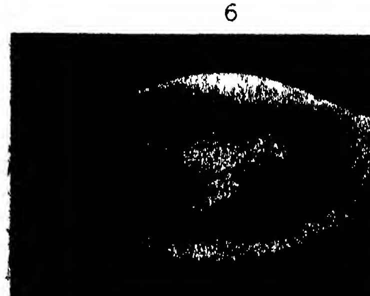

s by J. M Blake New Haven

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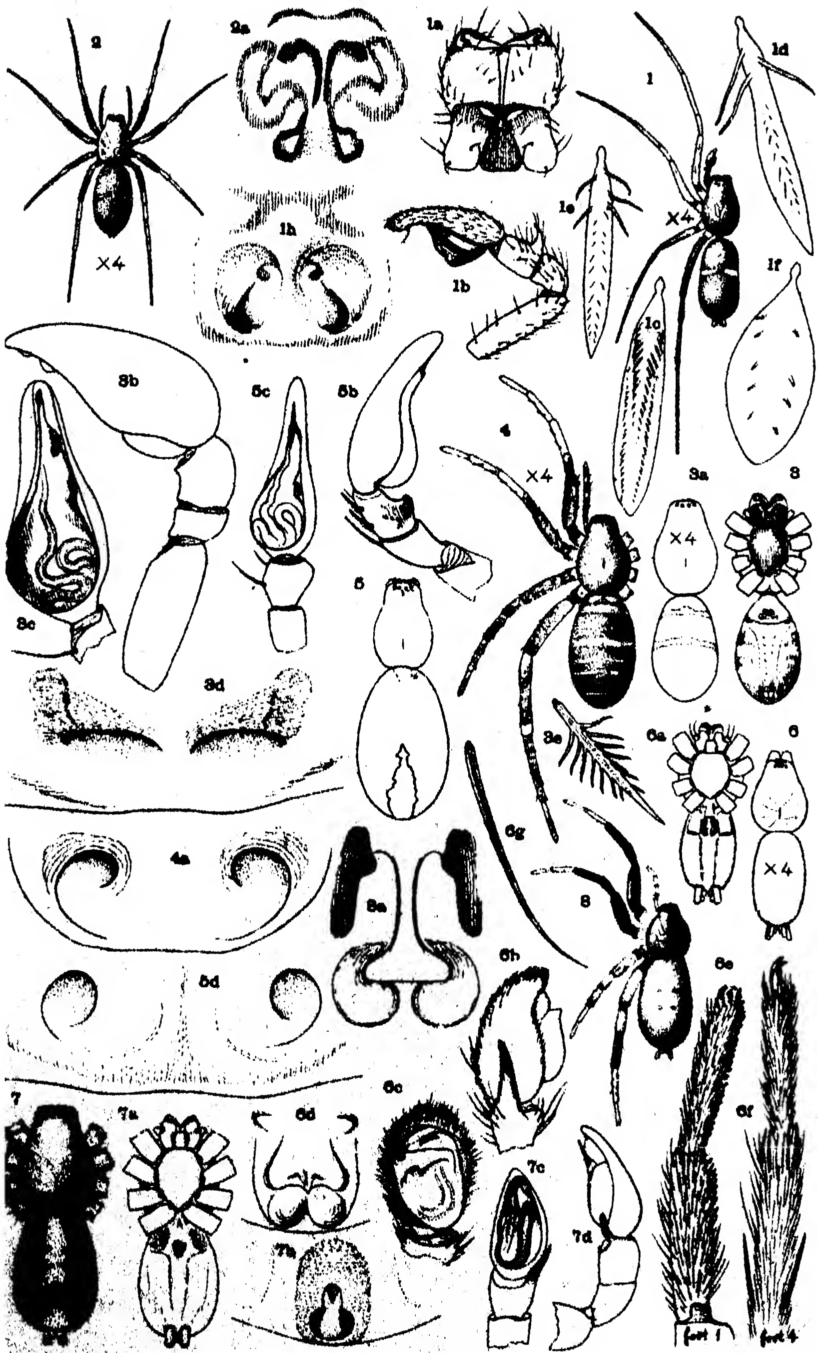
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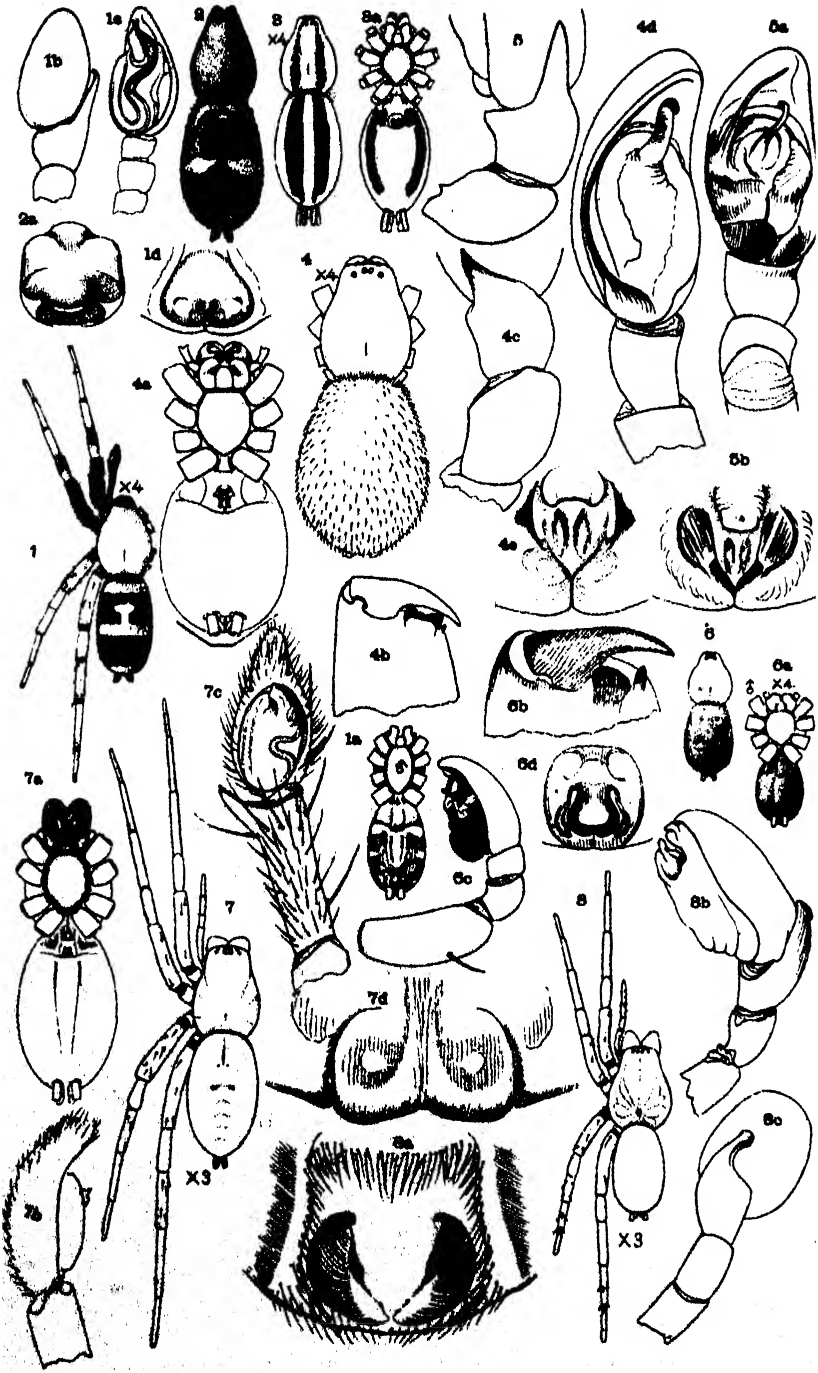
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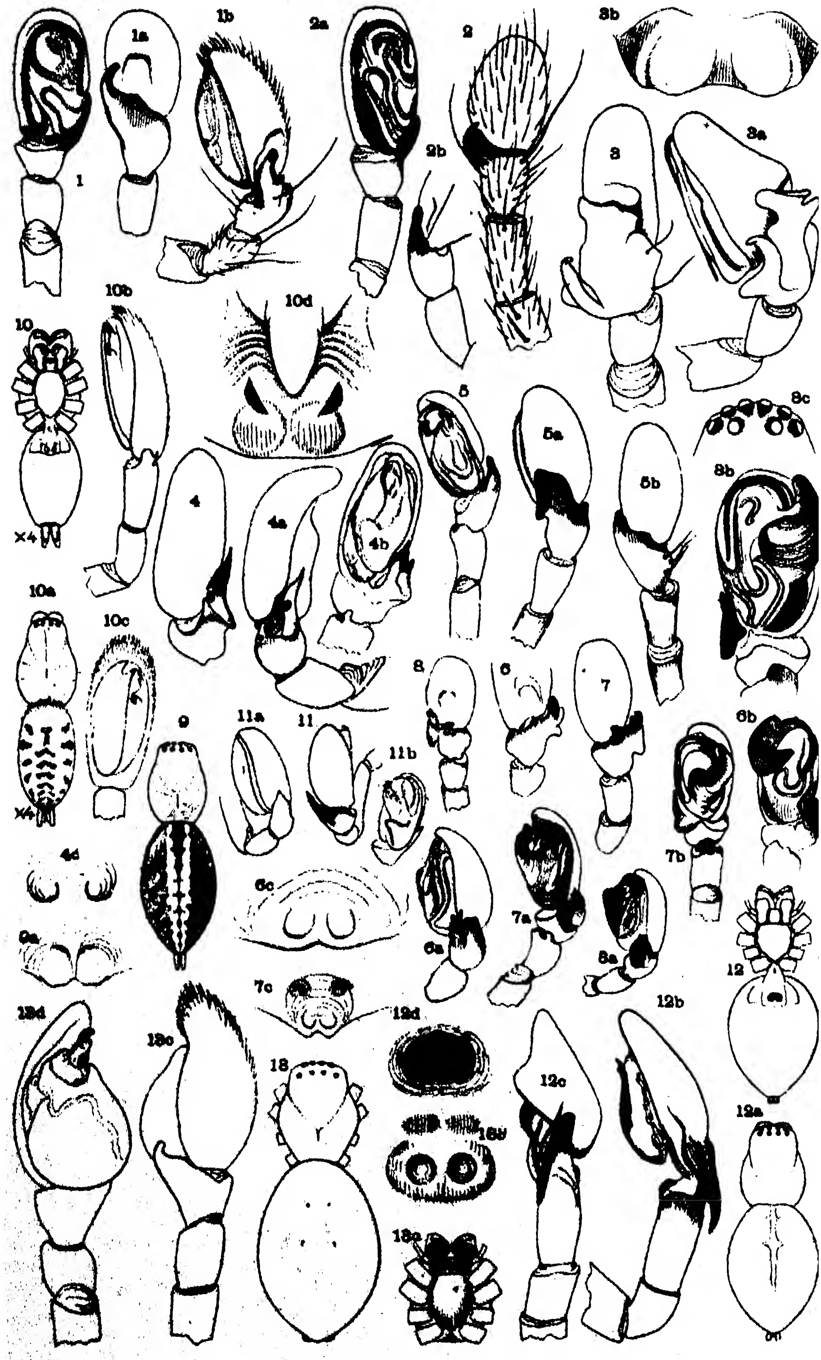
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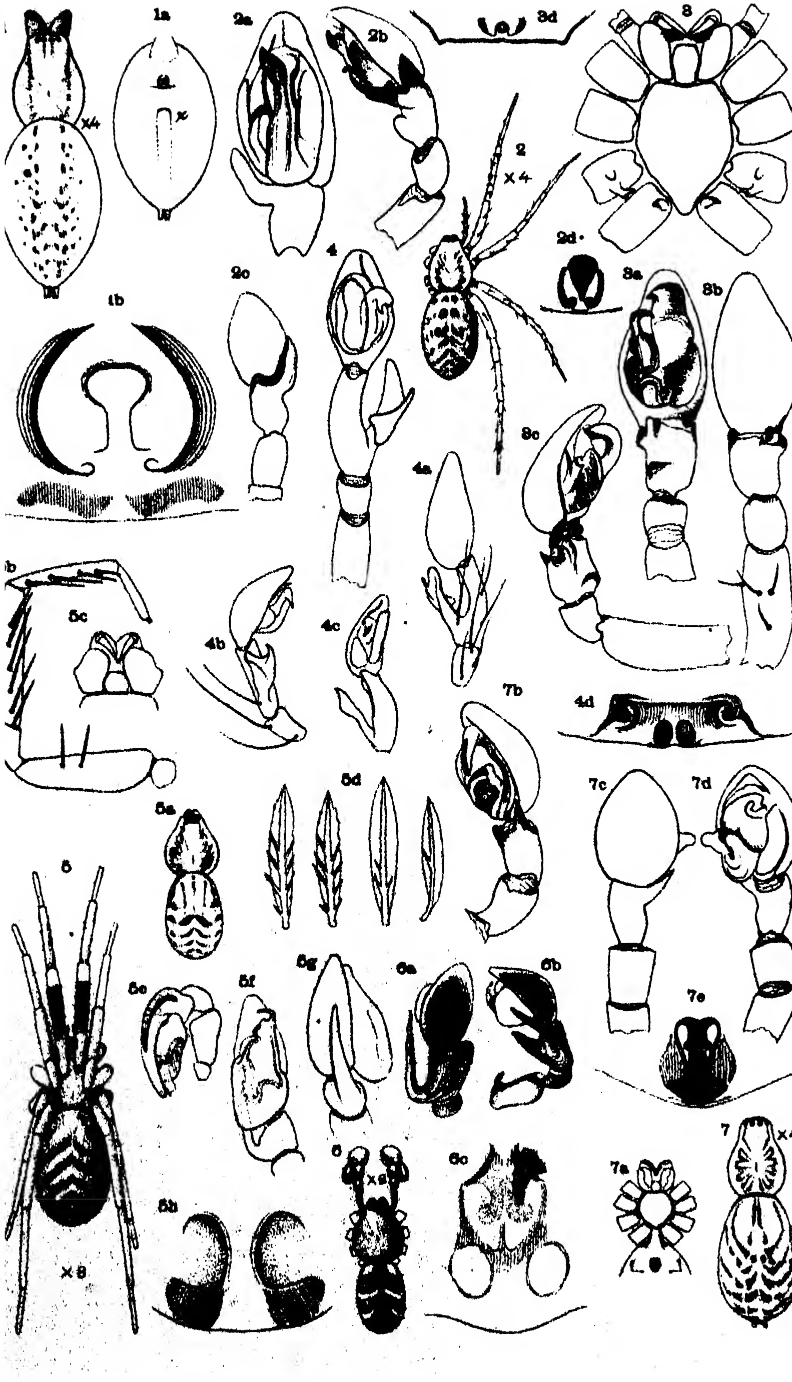
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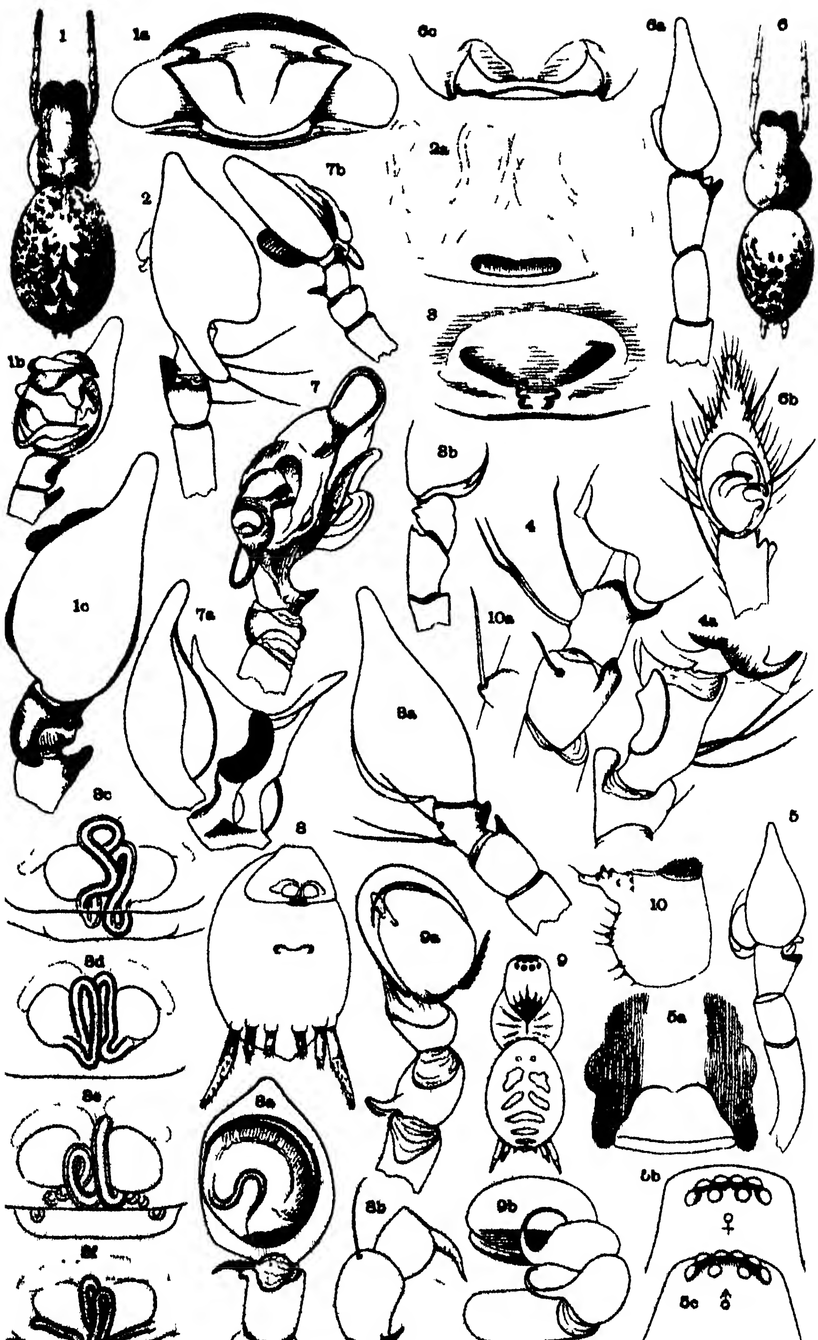

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1a
6c
6a
6
2a
7b
2
3
1b
7
6b
8b
4
1c
7a
10a
4a
8a
8c
8
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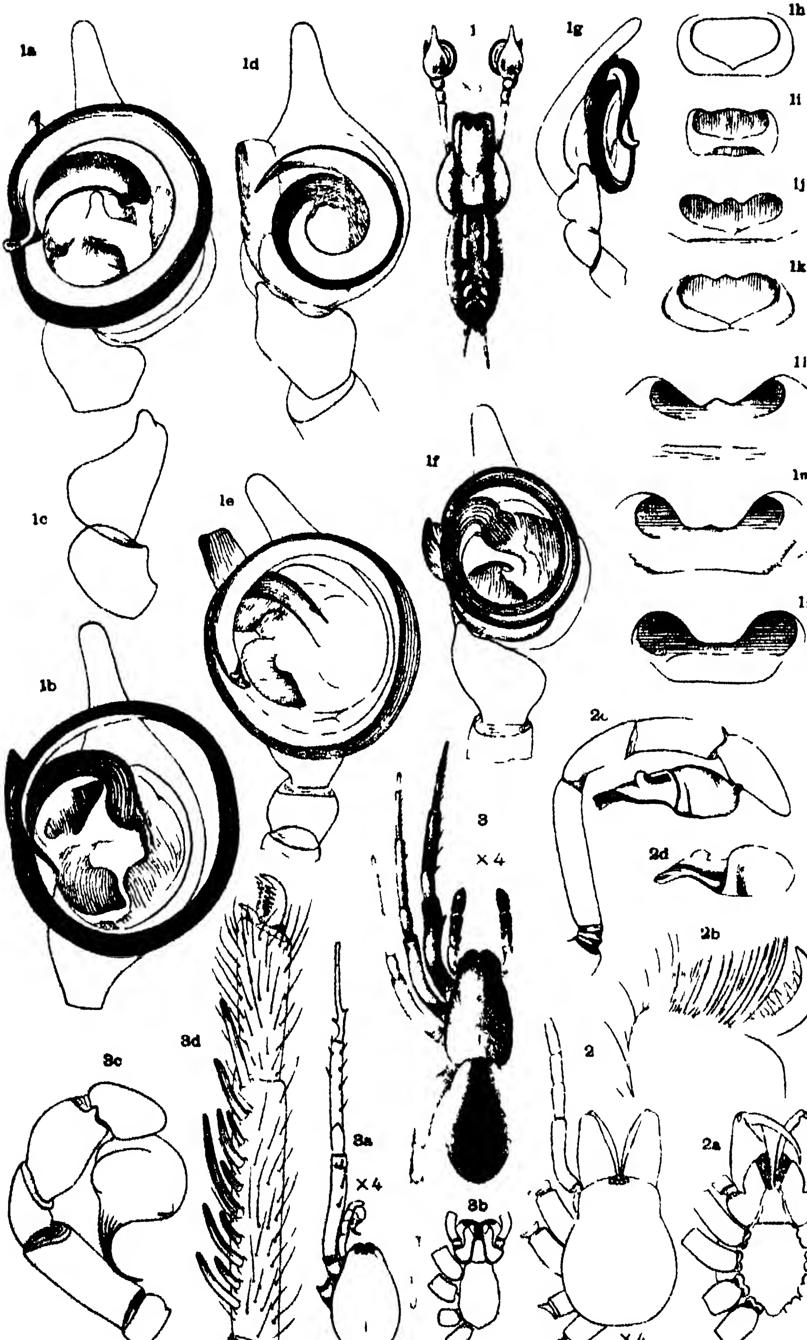
8d
9
5a
8e
8e
5b
8b
9b
♀
8f
5c
♂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1d
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1g
1h
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1j
1k
1l
1m
1n
1c
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1f
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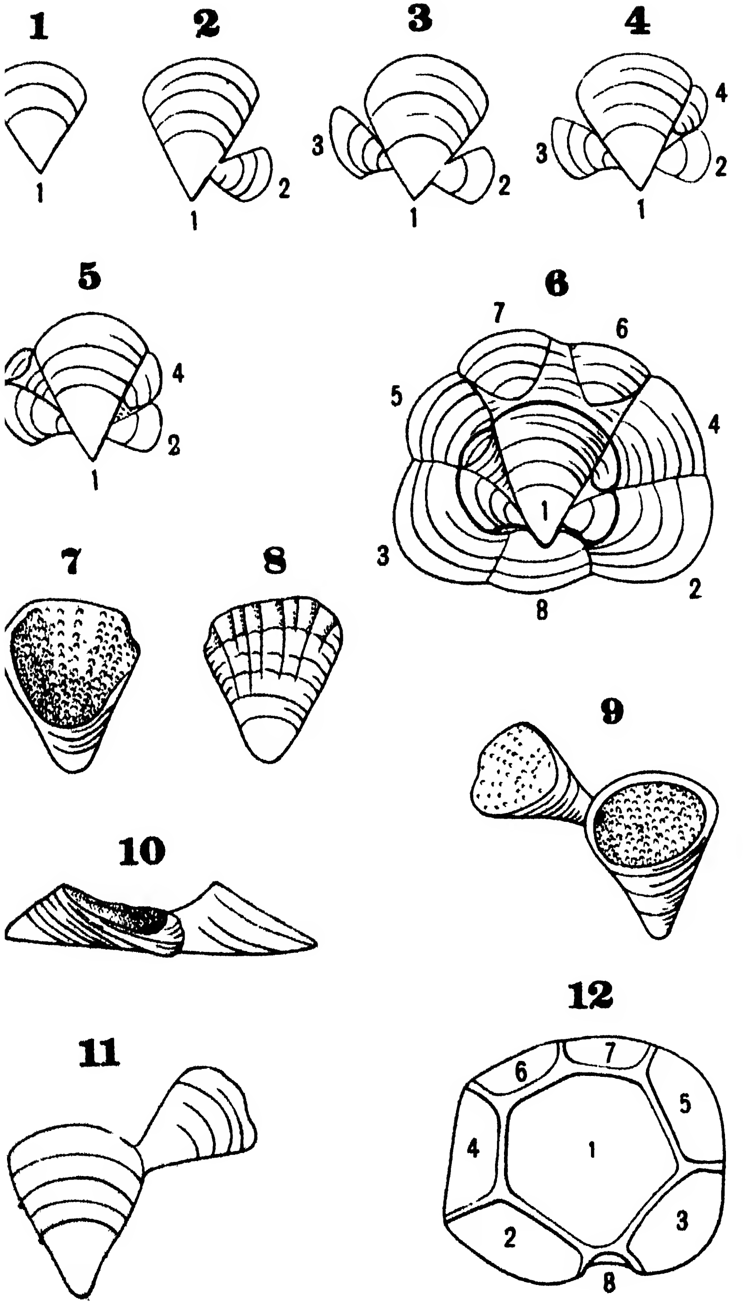
3
× 4
2d
2b
3c
3d
2
3a
× 4
3b
2a
× 4



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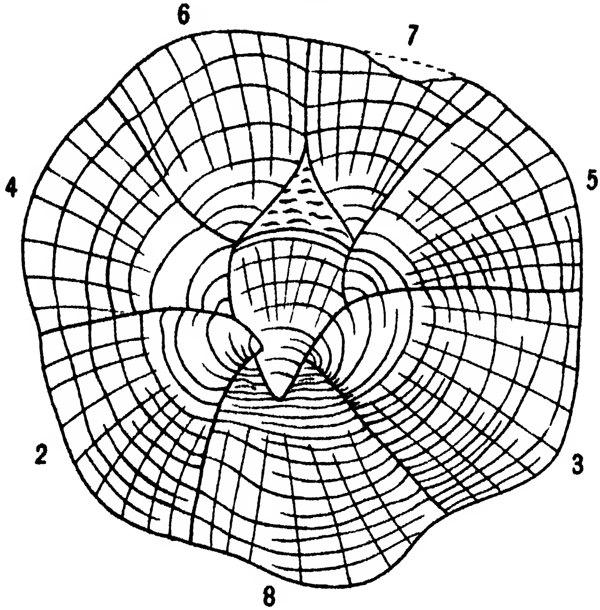

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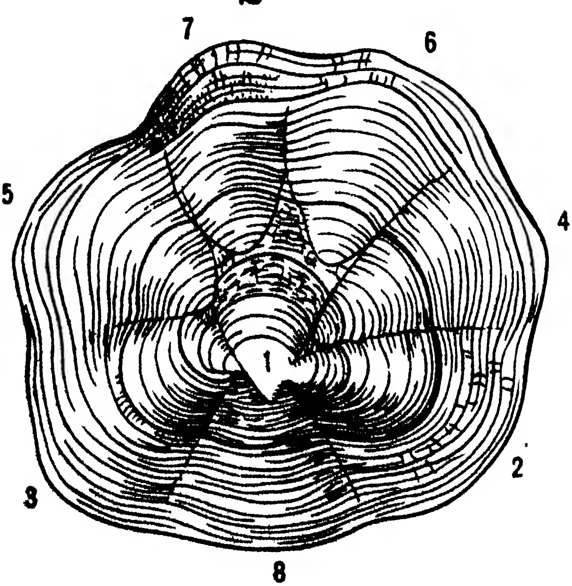

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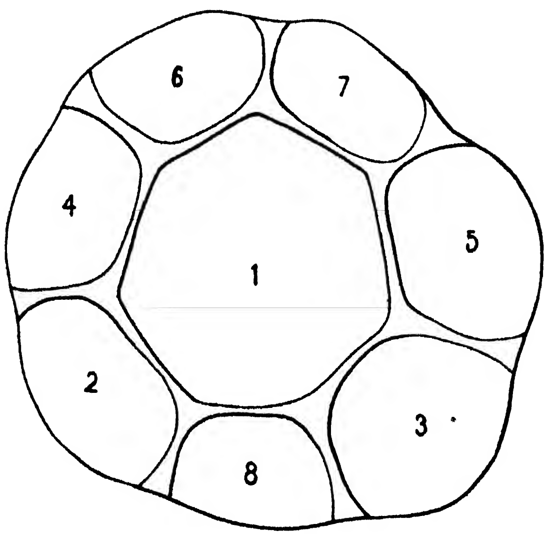

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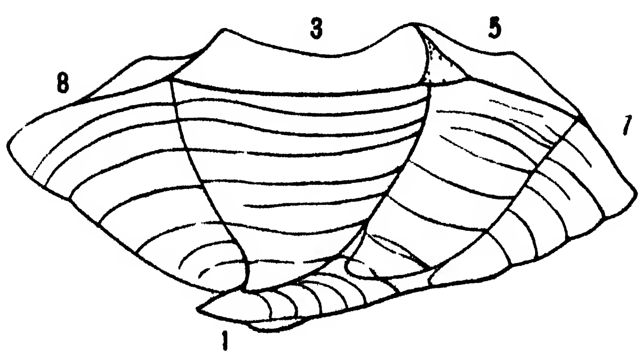

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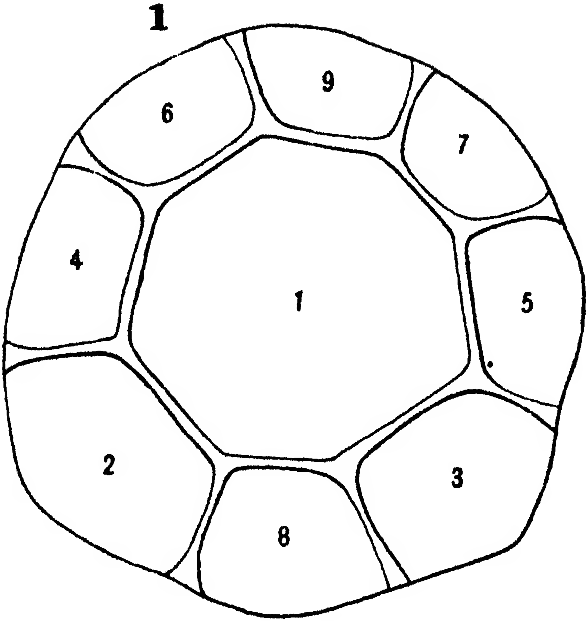

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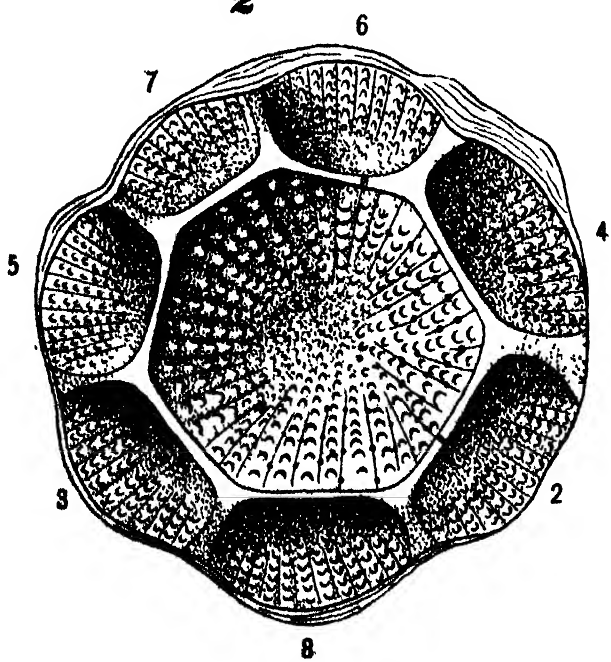

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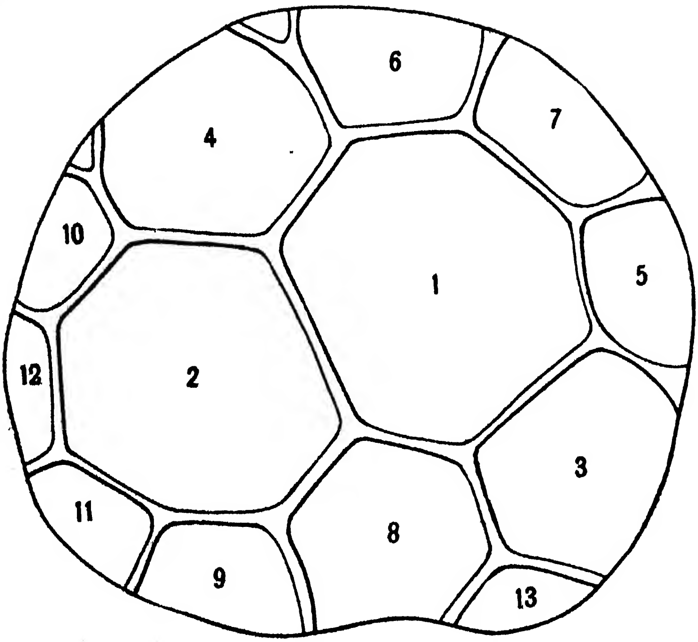

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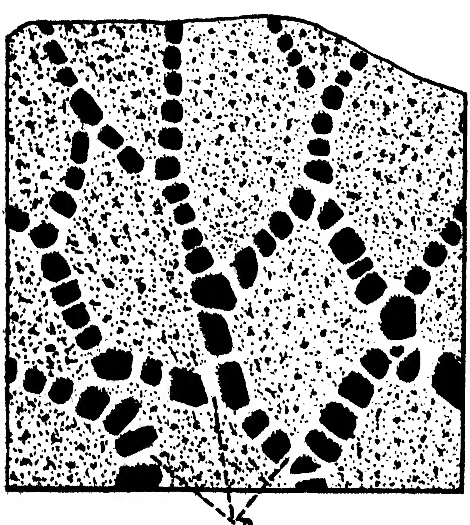

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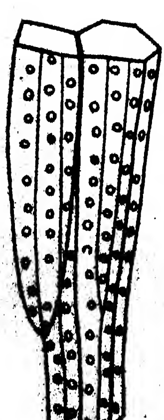

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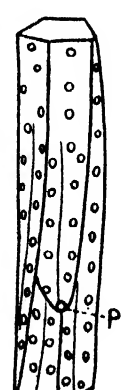

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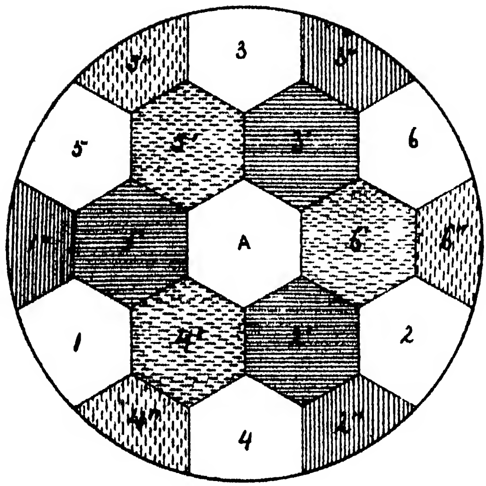

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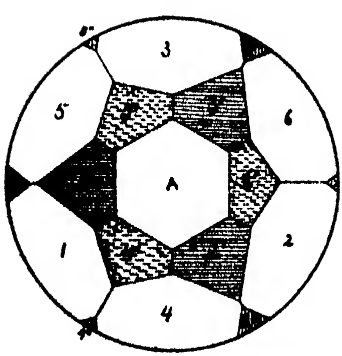

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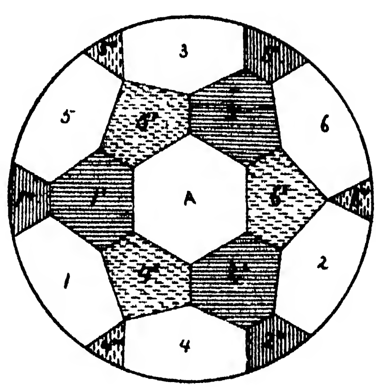

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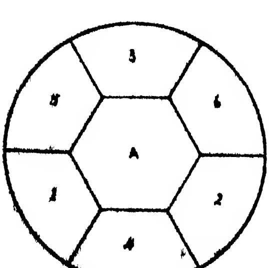

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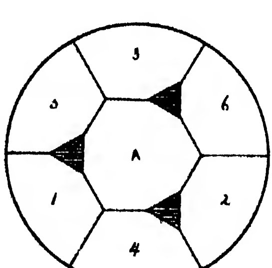

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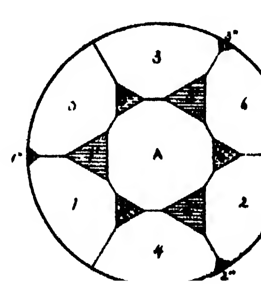

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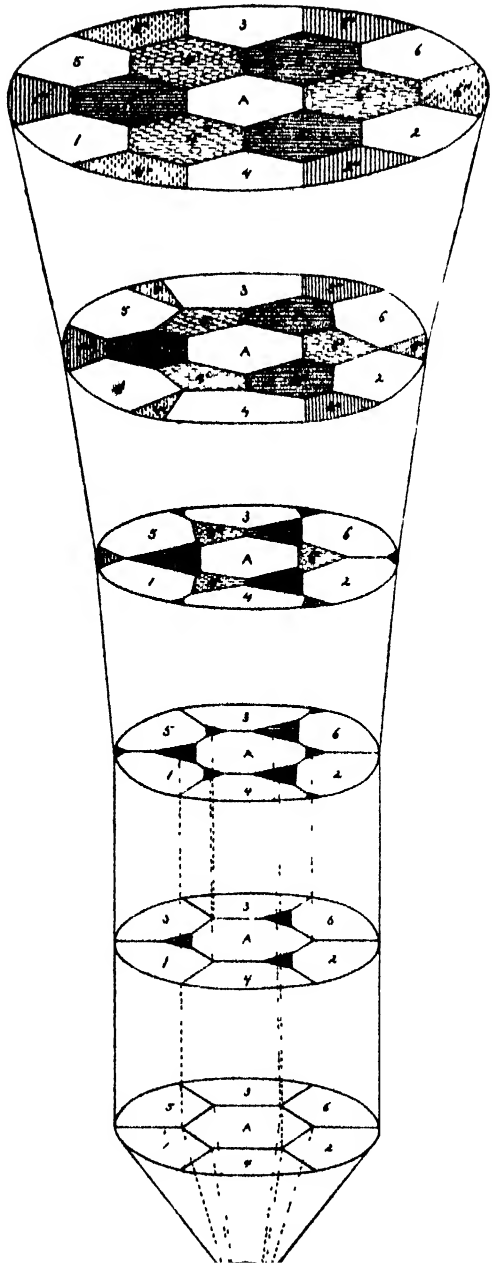

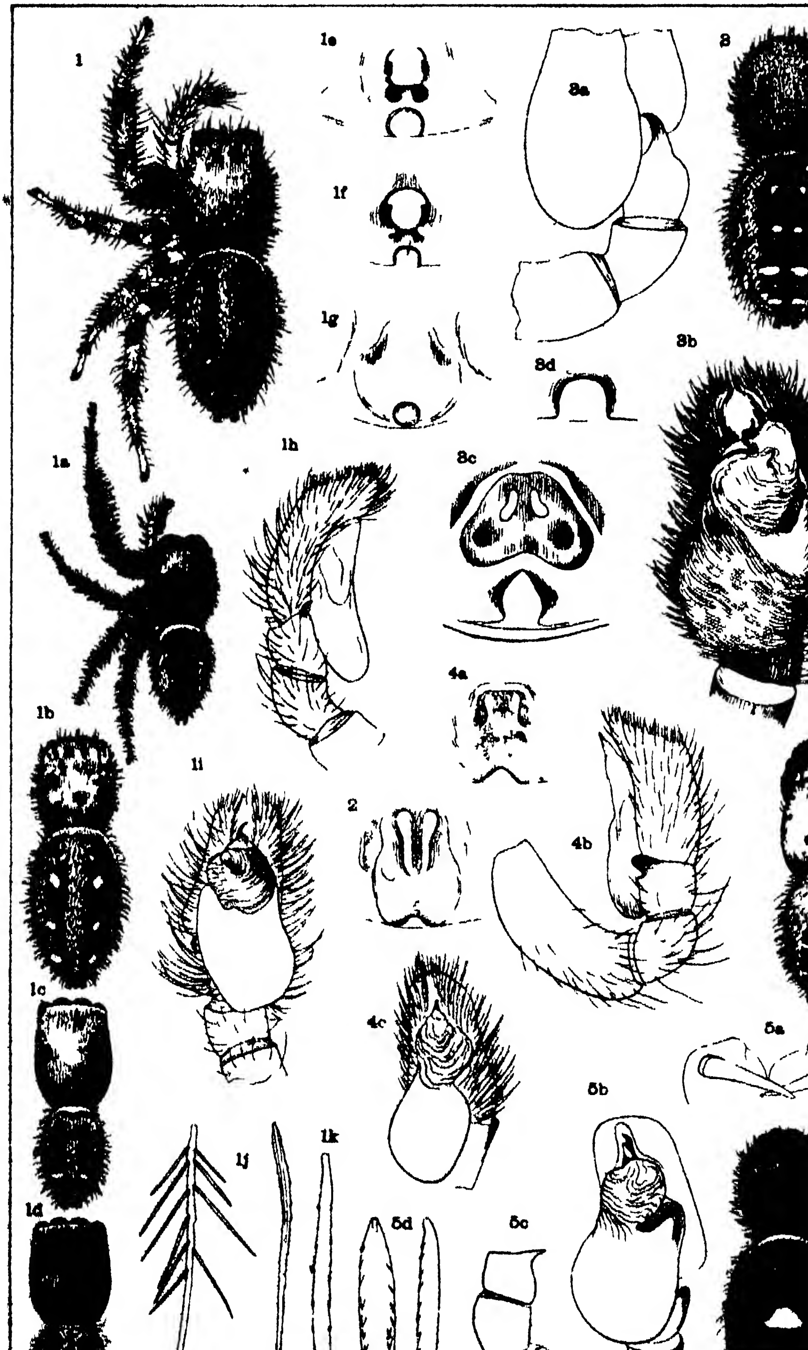
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1a
1b
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1g
1h
1i
1j
1k
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3
3a
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3d
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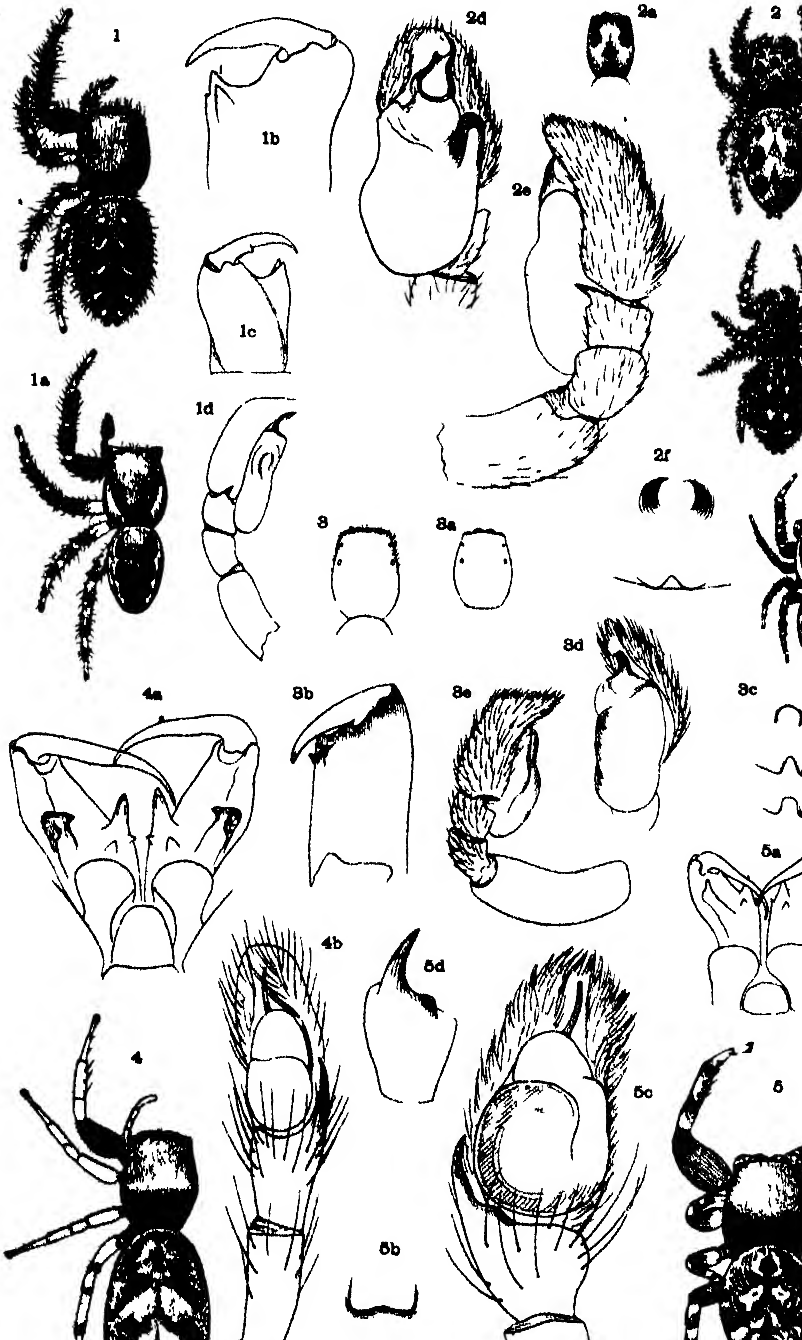
4b
4c
5a
5b
5c
5d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1d
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2d
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2f
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3d
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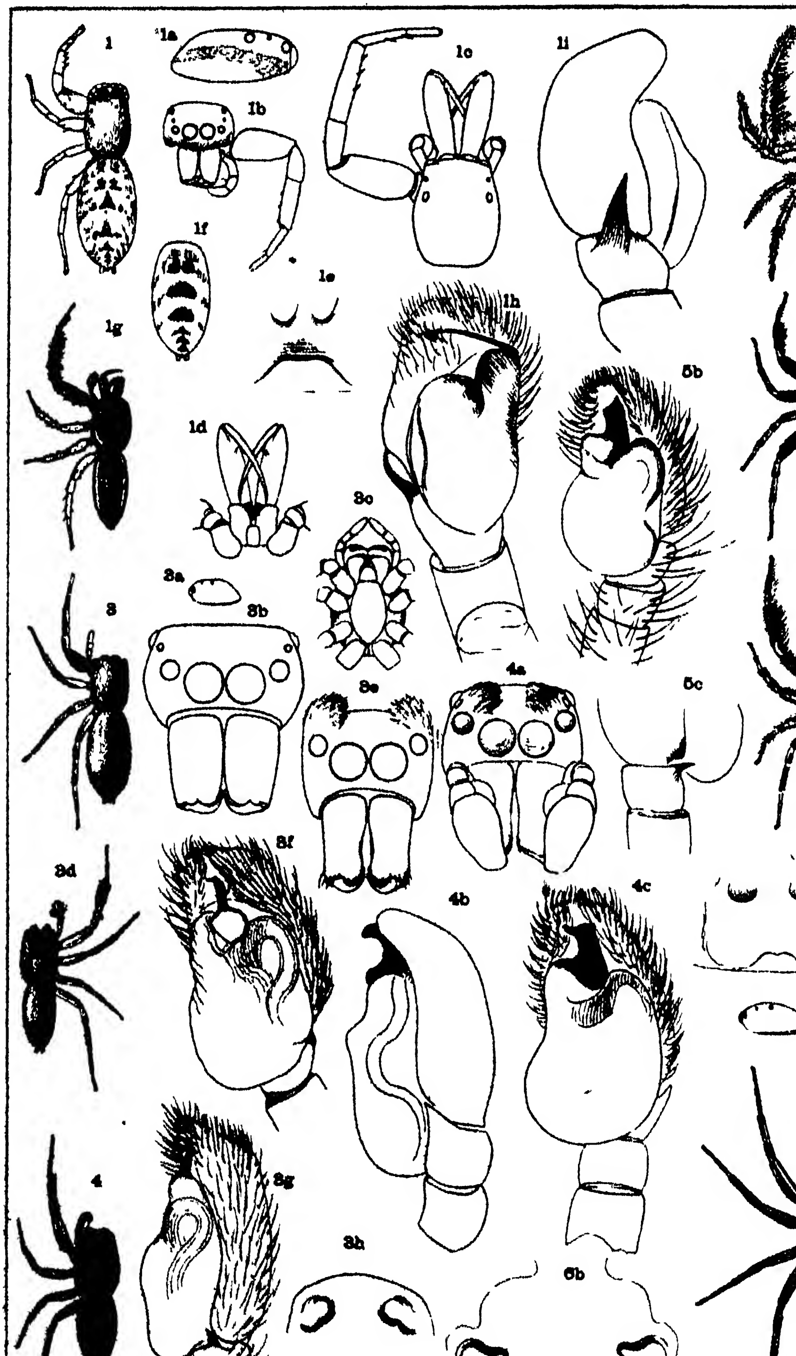
5a
5b
5c
5d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3h
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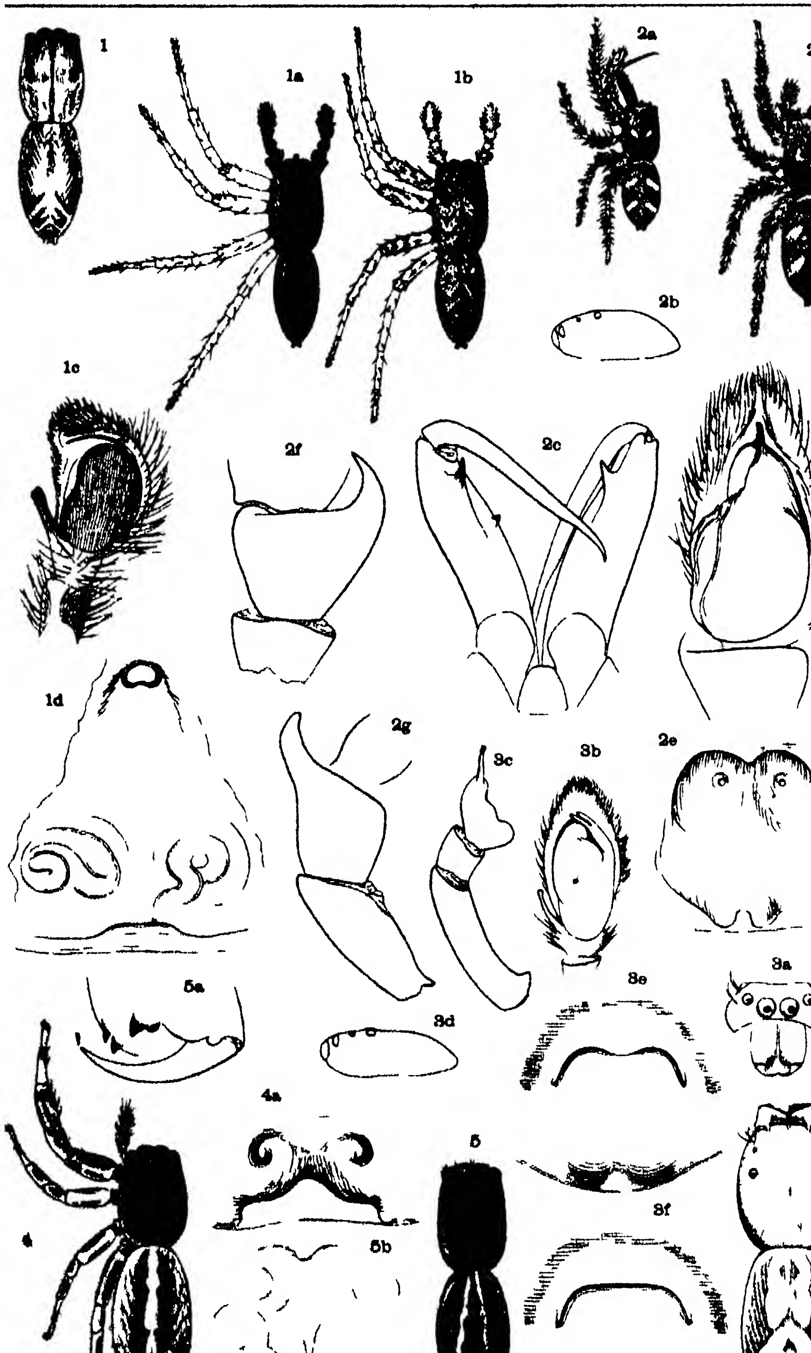
1
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1b
2a
2
2b
1c
2f
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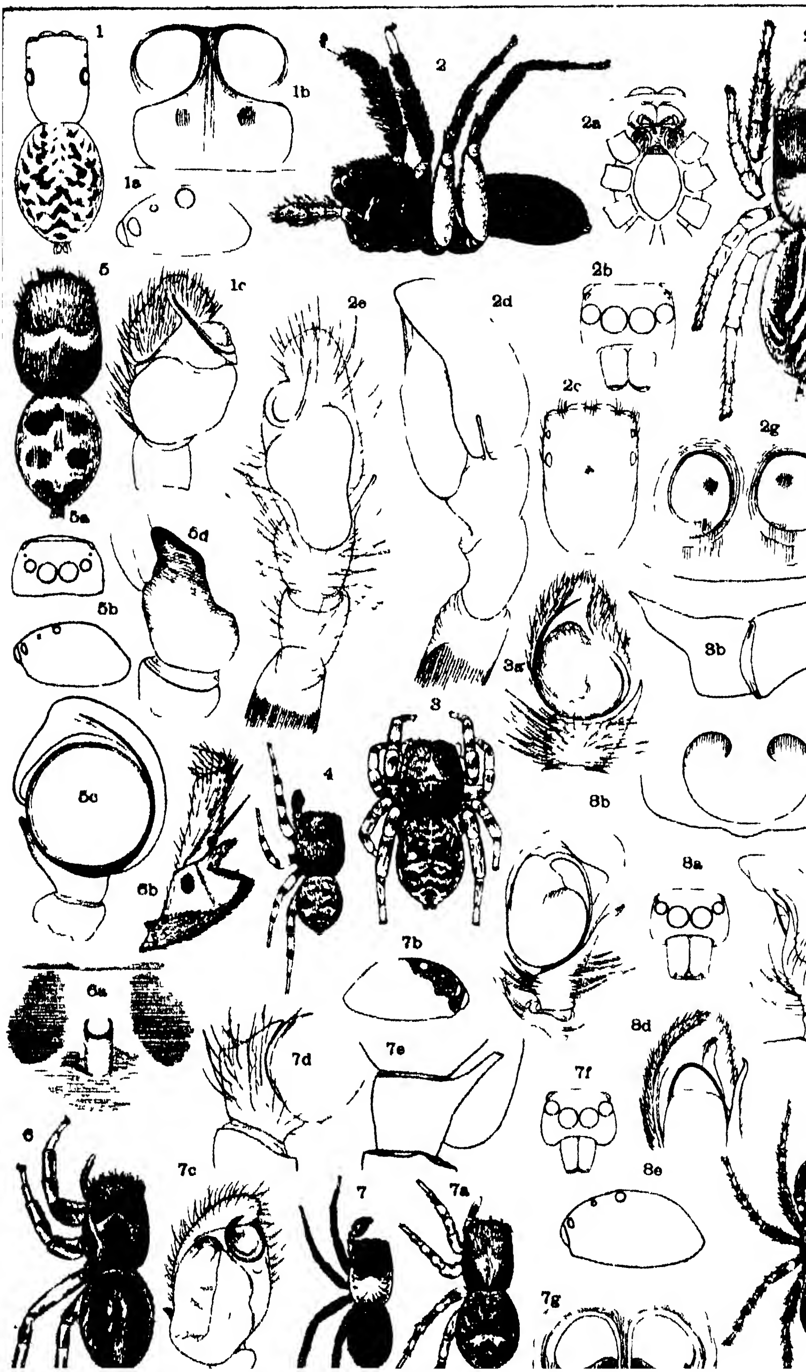
3b
2e
3a
5a
3e
3d
4a
5
4
3f
5b


1
1b
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2a
5
1c
2e
2d
2b
2c
2g
5a
5d
5b
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3a
8b
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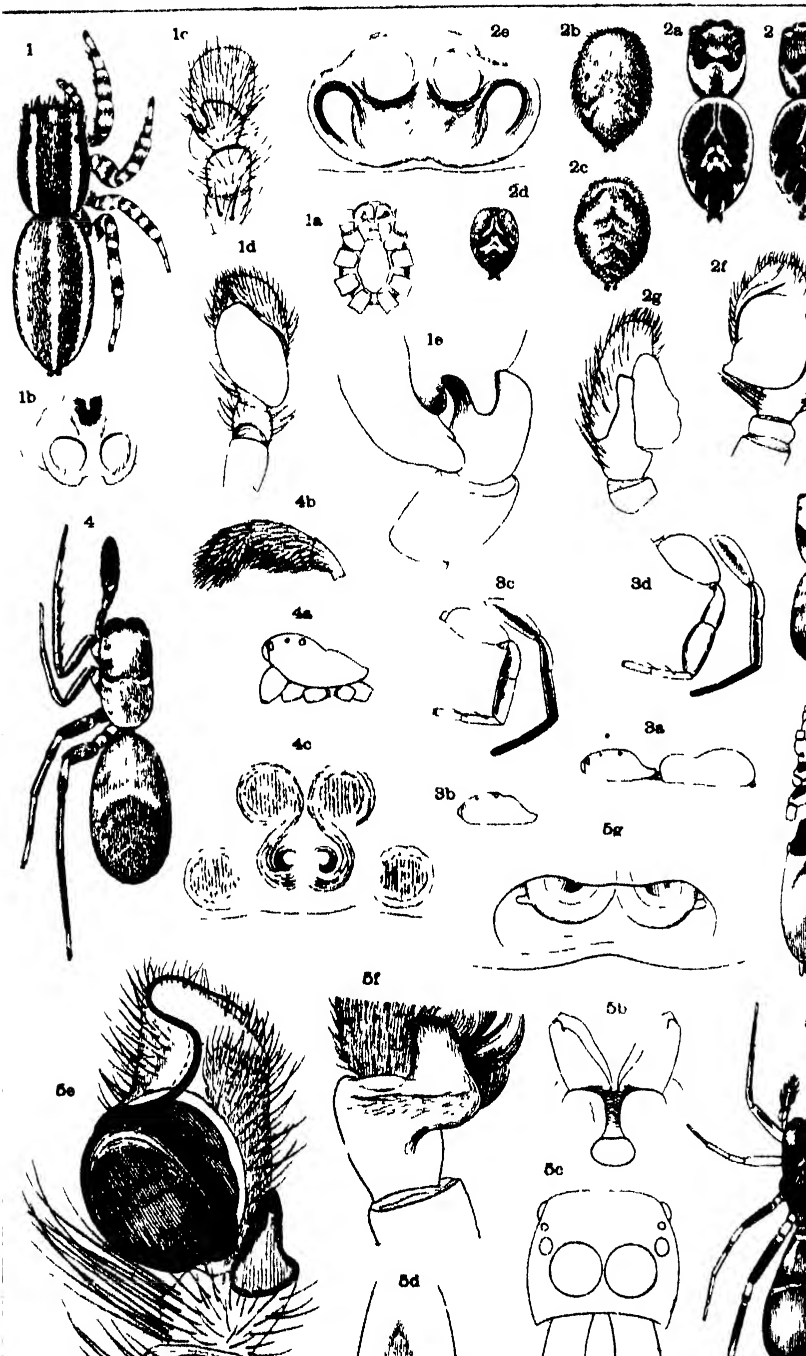
7
7a
8e
7g


1
1c
2e
2b
2a
2
2c
2d
1a
1d
2f
2g
1e
1b
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3d
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3b
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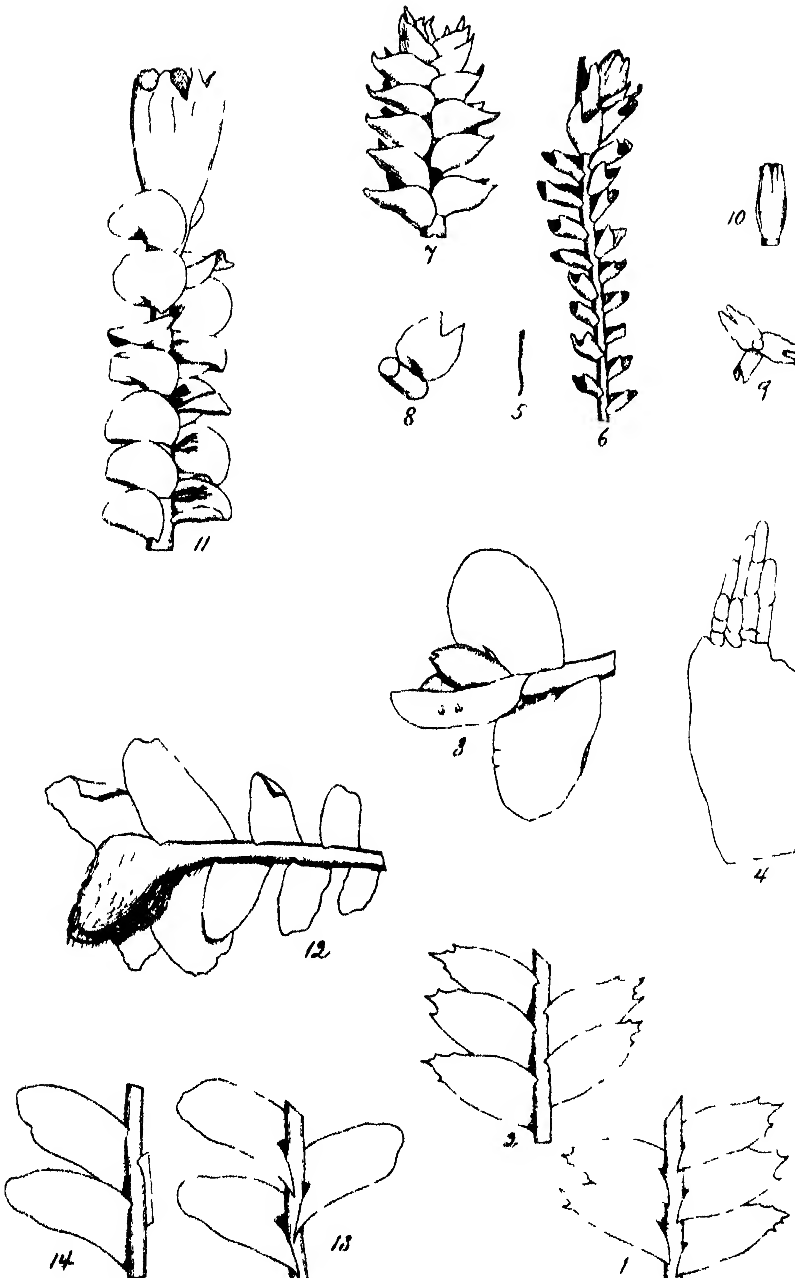
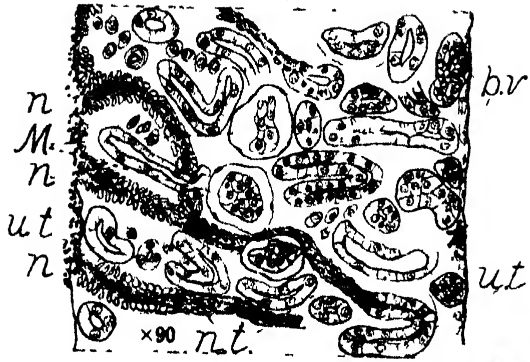
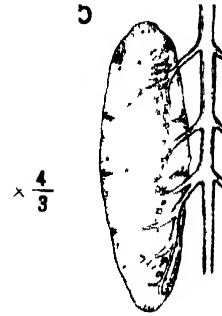
5f
5b
5
5e
5c
5d


7
6
10
11
8
5
9
3
4
12
2
14
13
1

1


n
M.
n
u.t
n
b.v
u.t
n.t.
×90

5


× 4/3

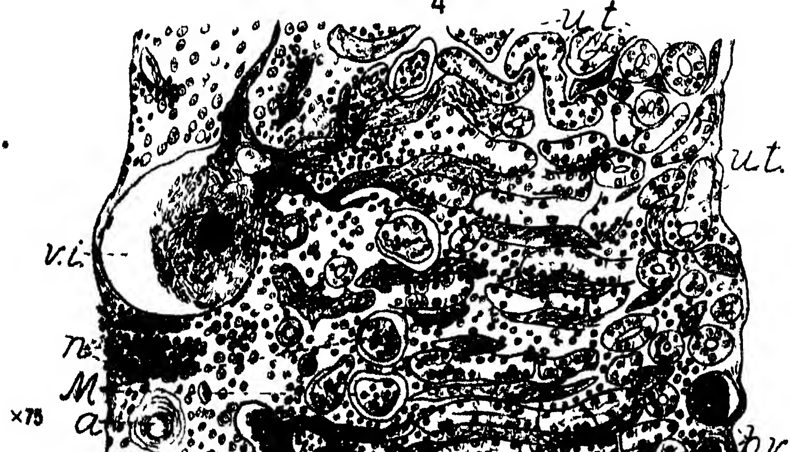
3


b.v.
c
n
×270

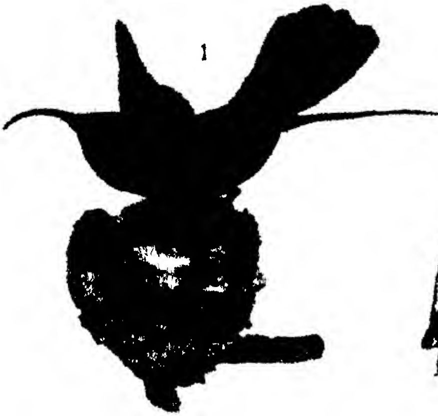
2


u.t.
n
b.v
n
n.t
n
b.v
×100

4


u.t
u.t.
v.i.
n
M
a
b.v.
×75

1

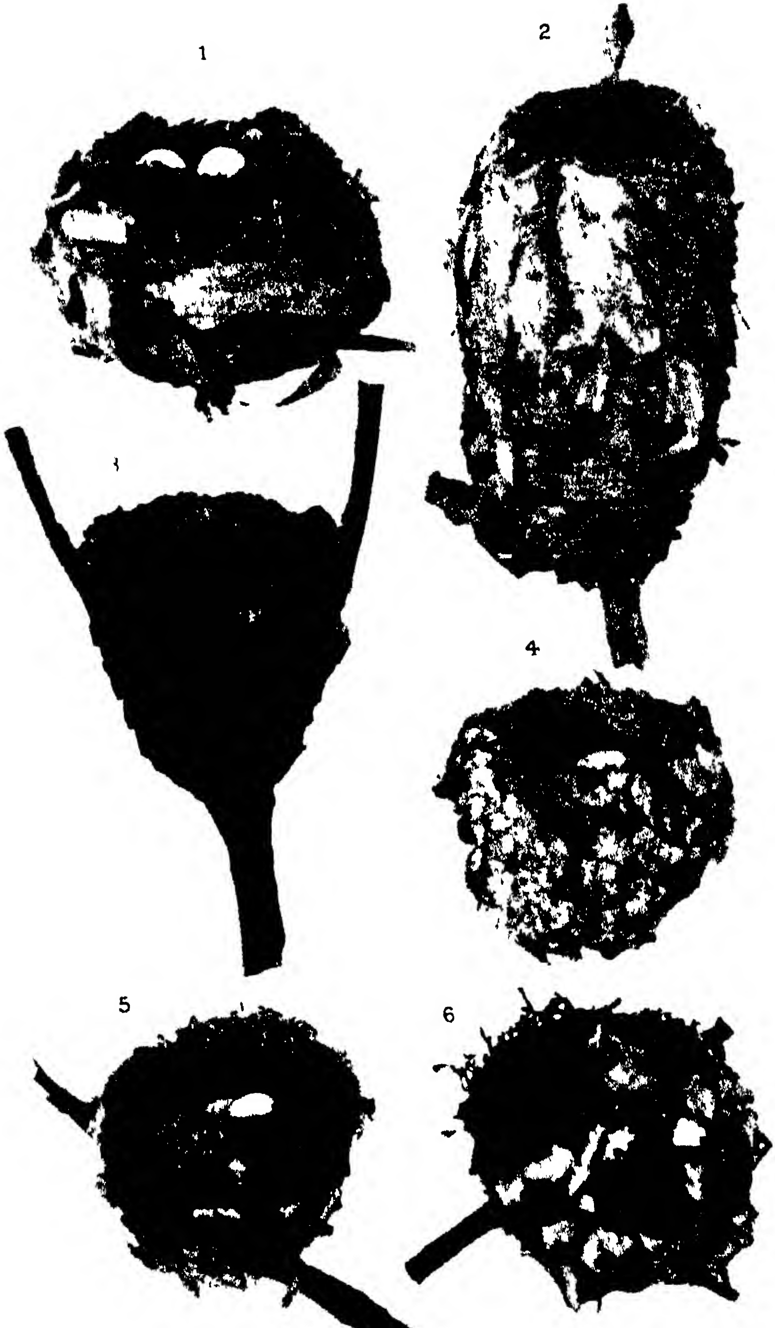


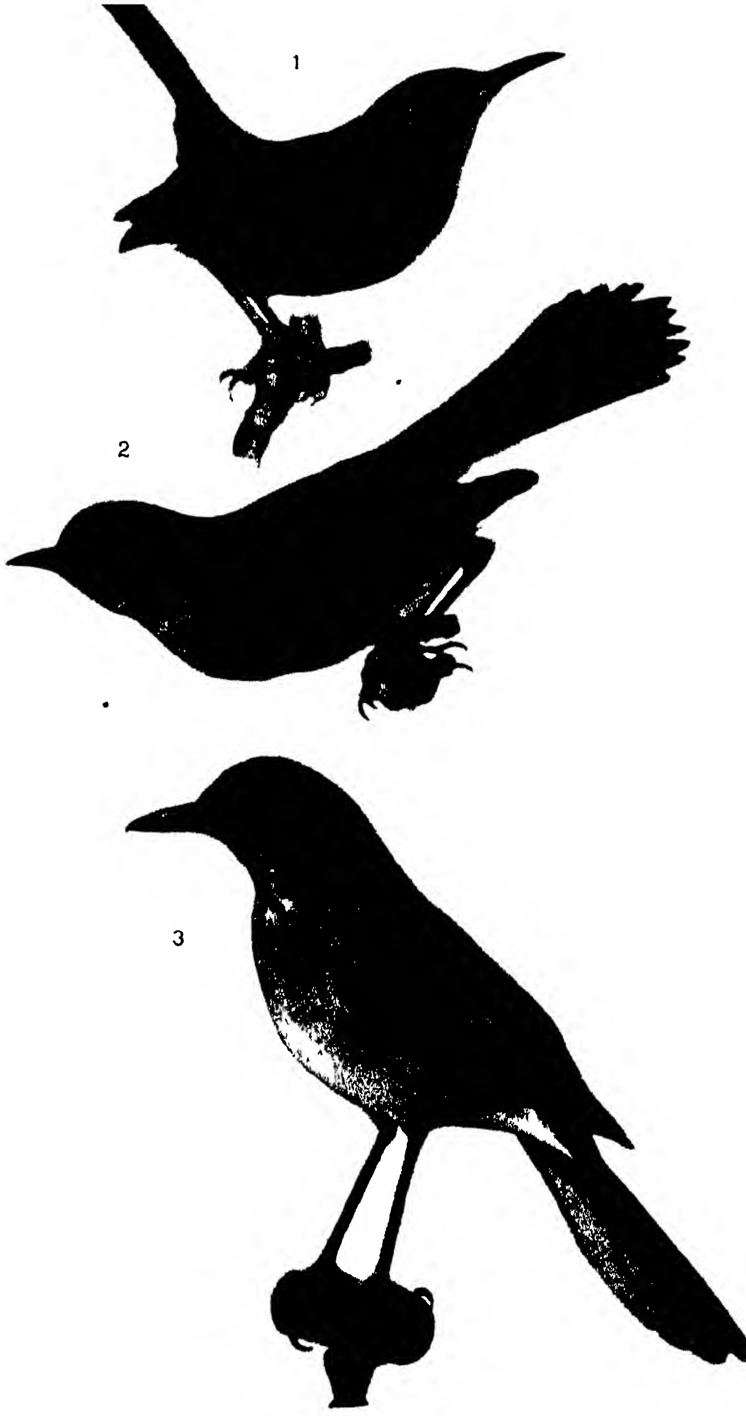
3

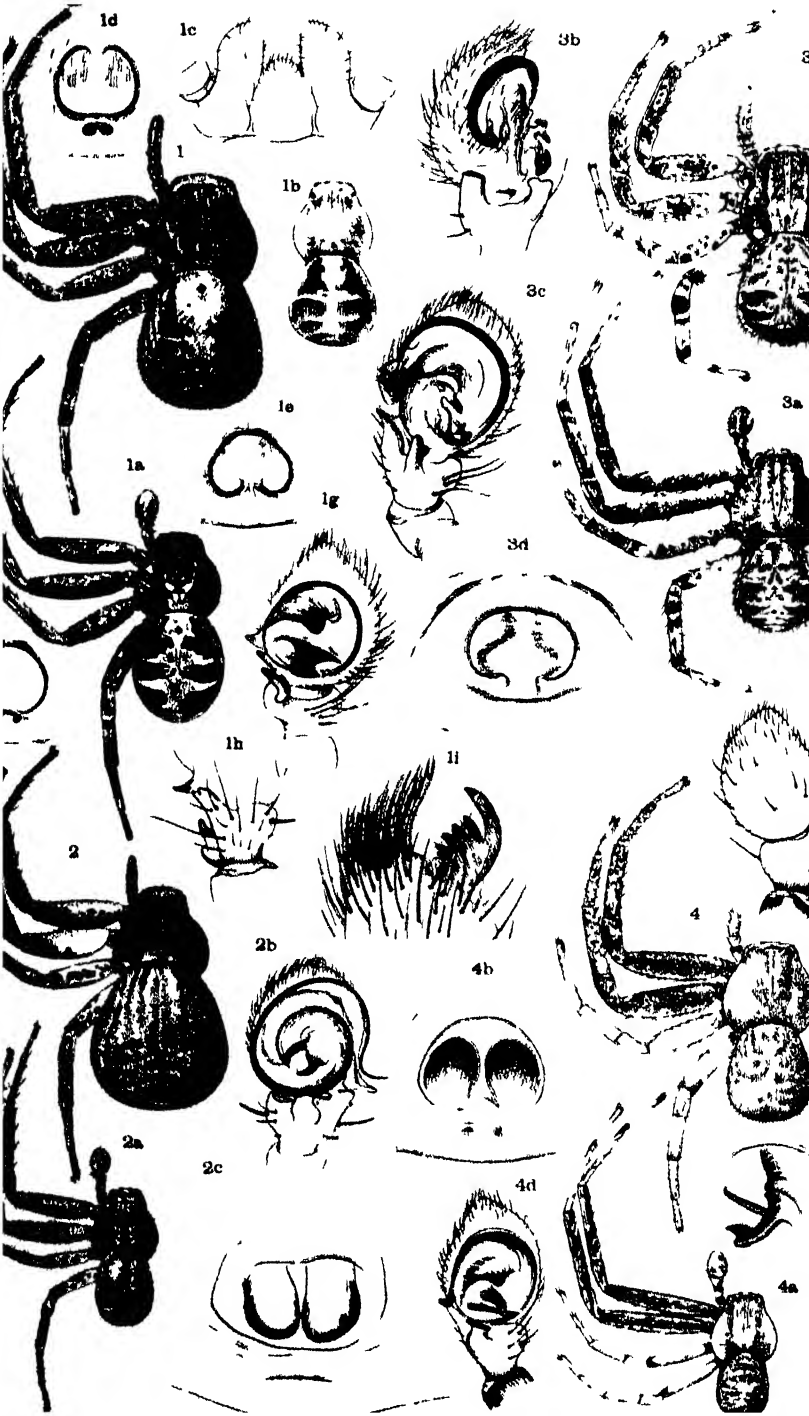
2

4

5 6 7 8 9 10 11


1
2
4
5
6


1
2
3


1d
1c
3b
3
1
1b
3c
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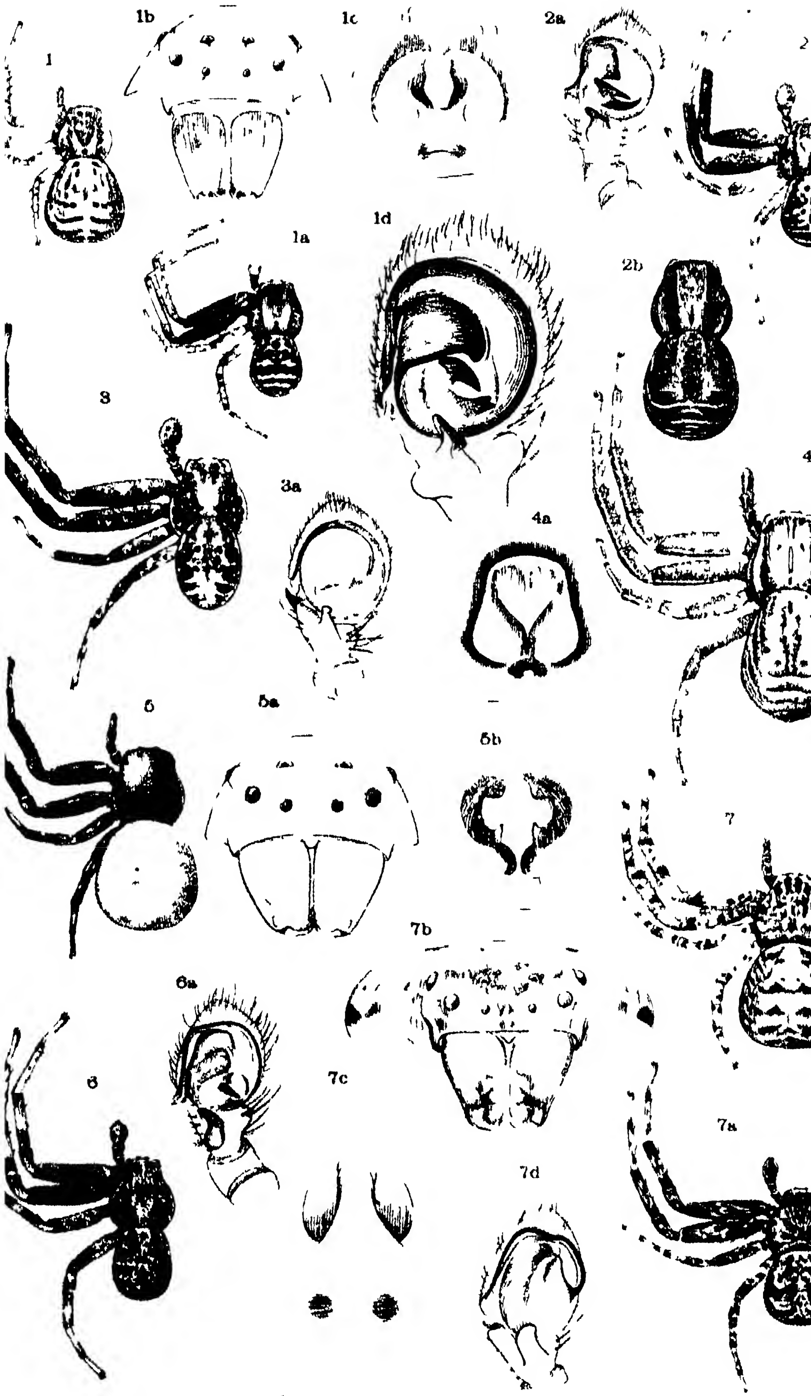
3a
1a
1g
3d
1h
1i
2
2b
4b
4
2a
2c
4d
4a


1
1b
1c
2a
2
1a
1d
2b
3
3a
4a
4
5
5a
5b
7
7b
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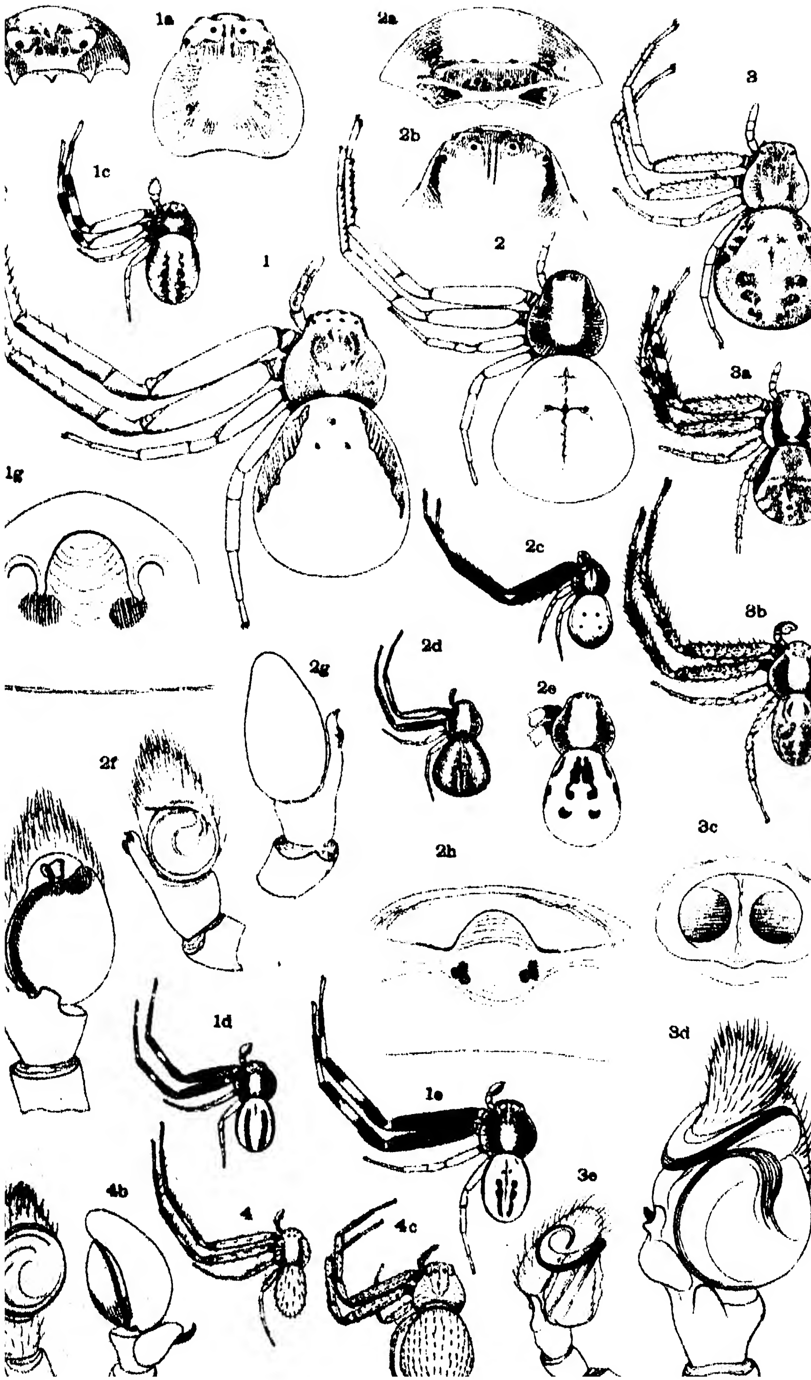
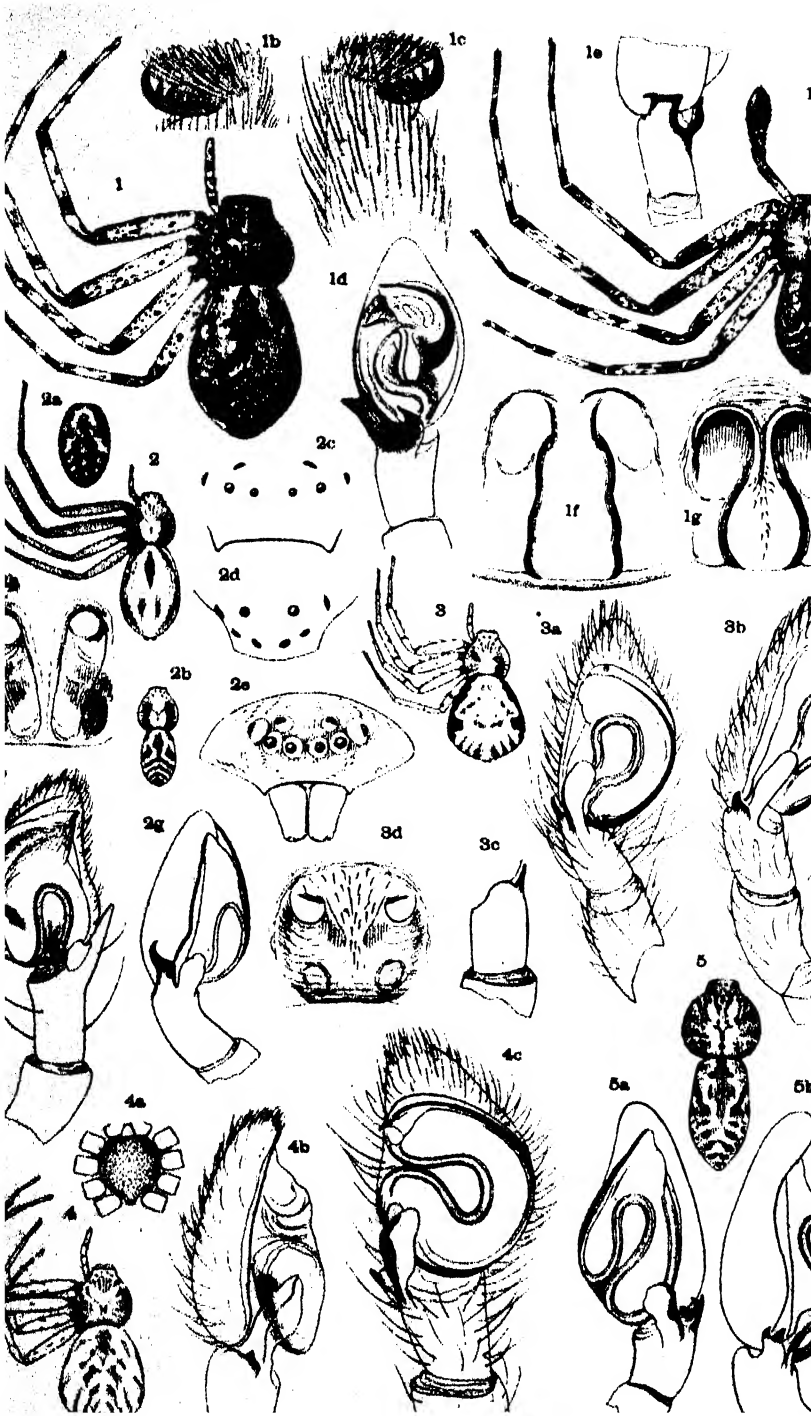
6
7c
7d
7a


1a
2a
3
2b
1c
2
1
3a
1g
2c
3b
2d
2g
2e
2f
3c
2h
1d
3d
1e
4b
4
4c
3e


1b
1c
1e
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1d
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2
2c
1f
1g
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2g
3d
3c
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4c
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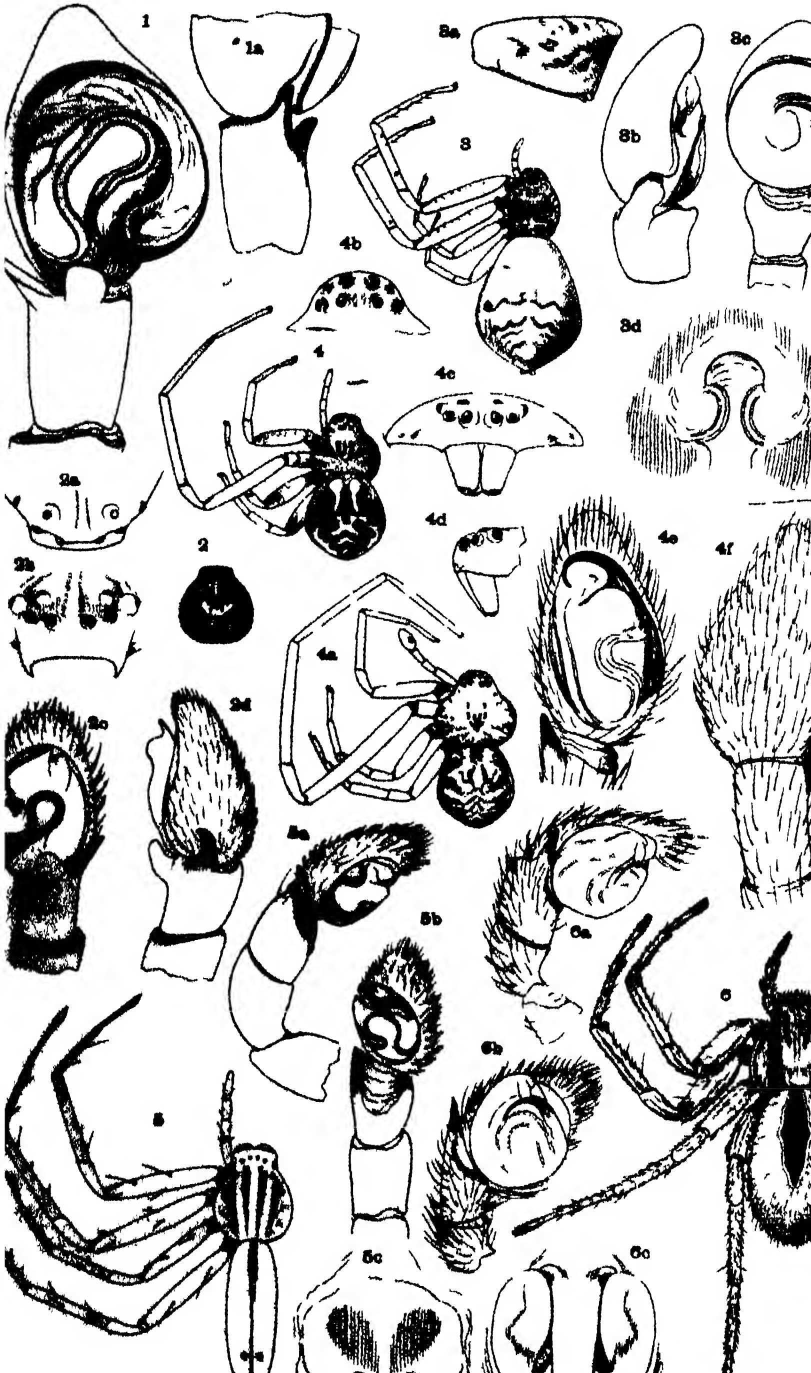
5b
4a
4b
4


1
1a
3a
3b
3c
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4b
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4c
3d
2a
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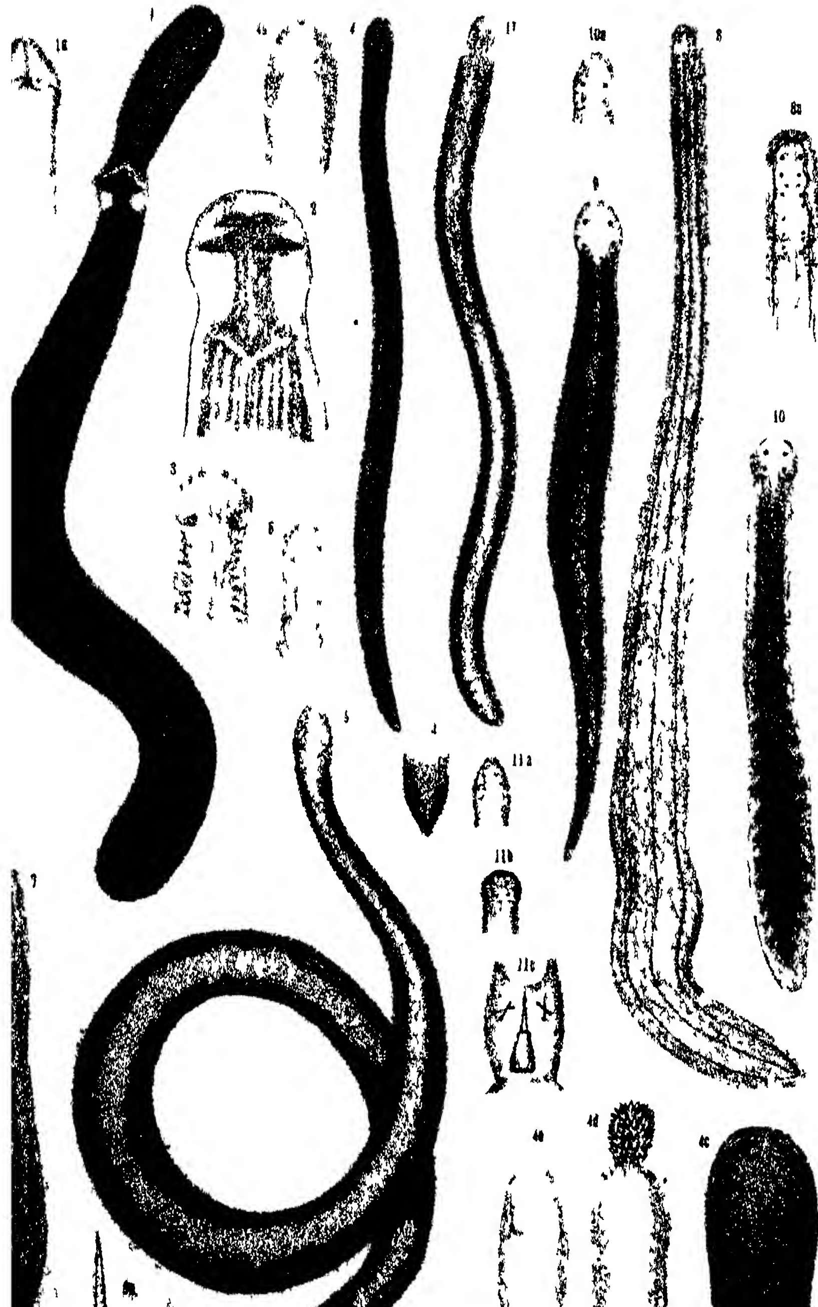
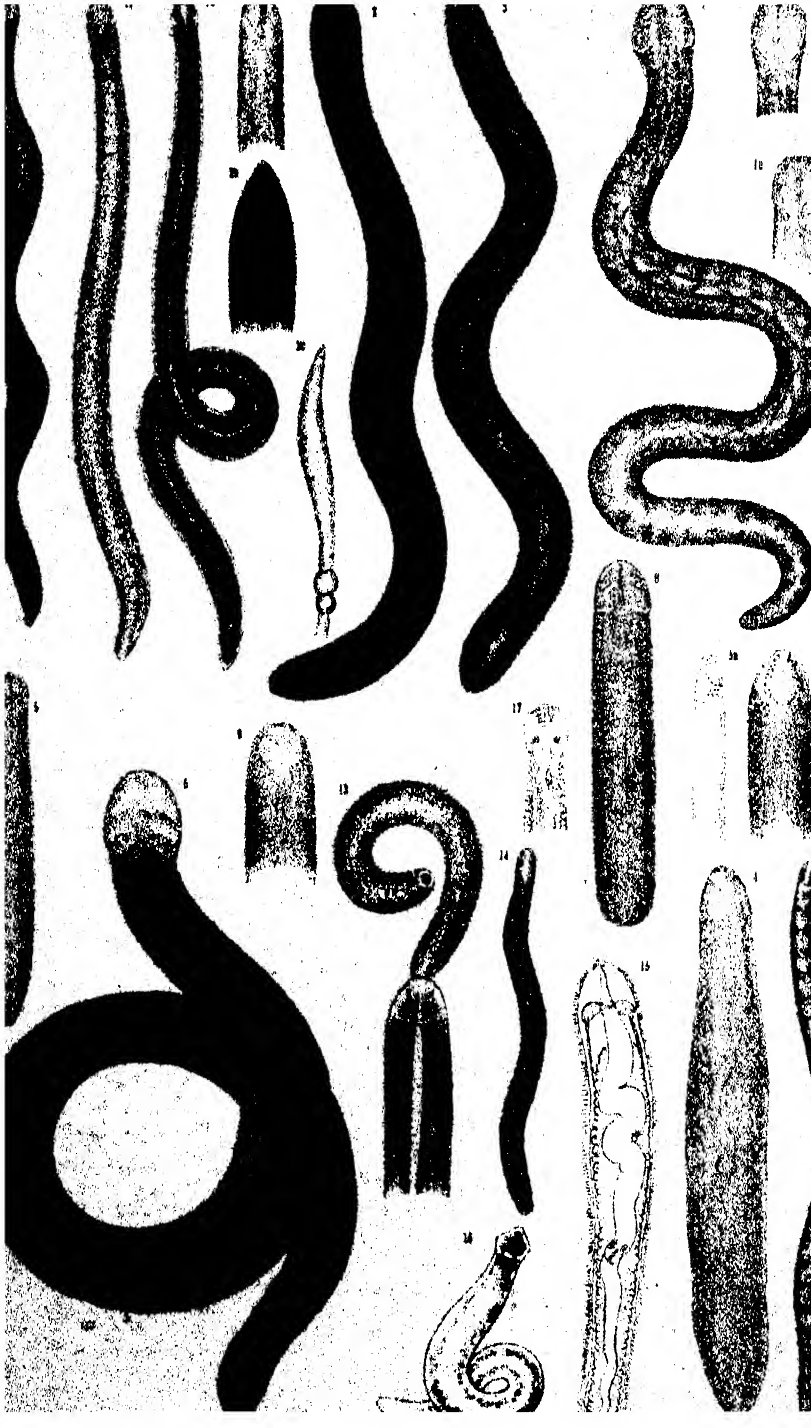
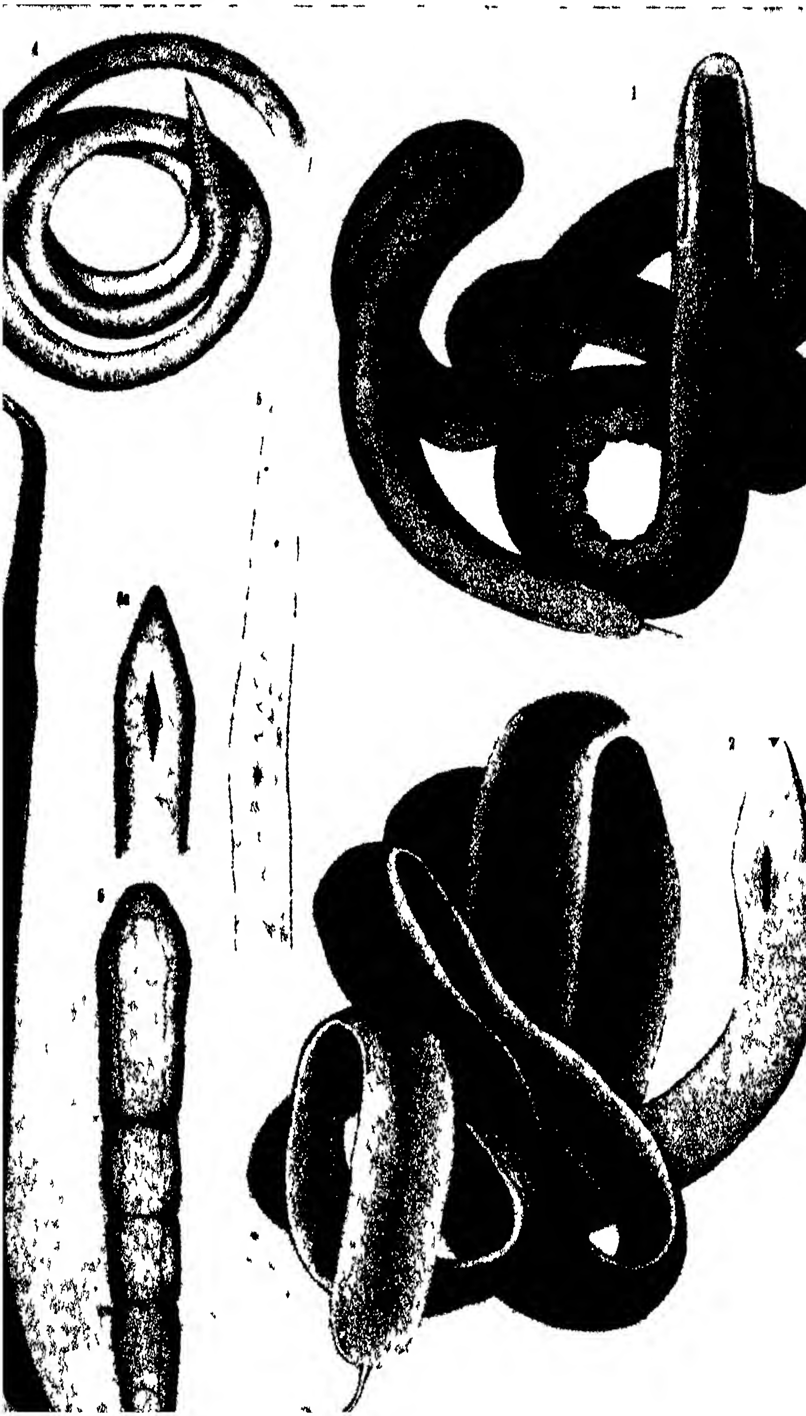
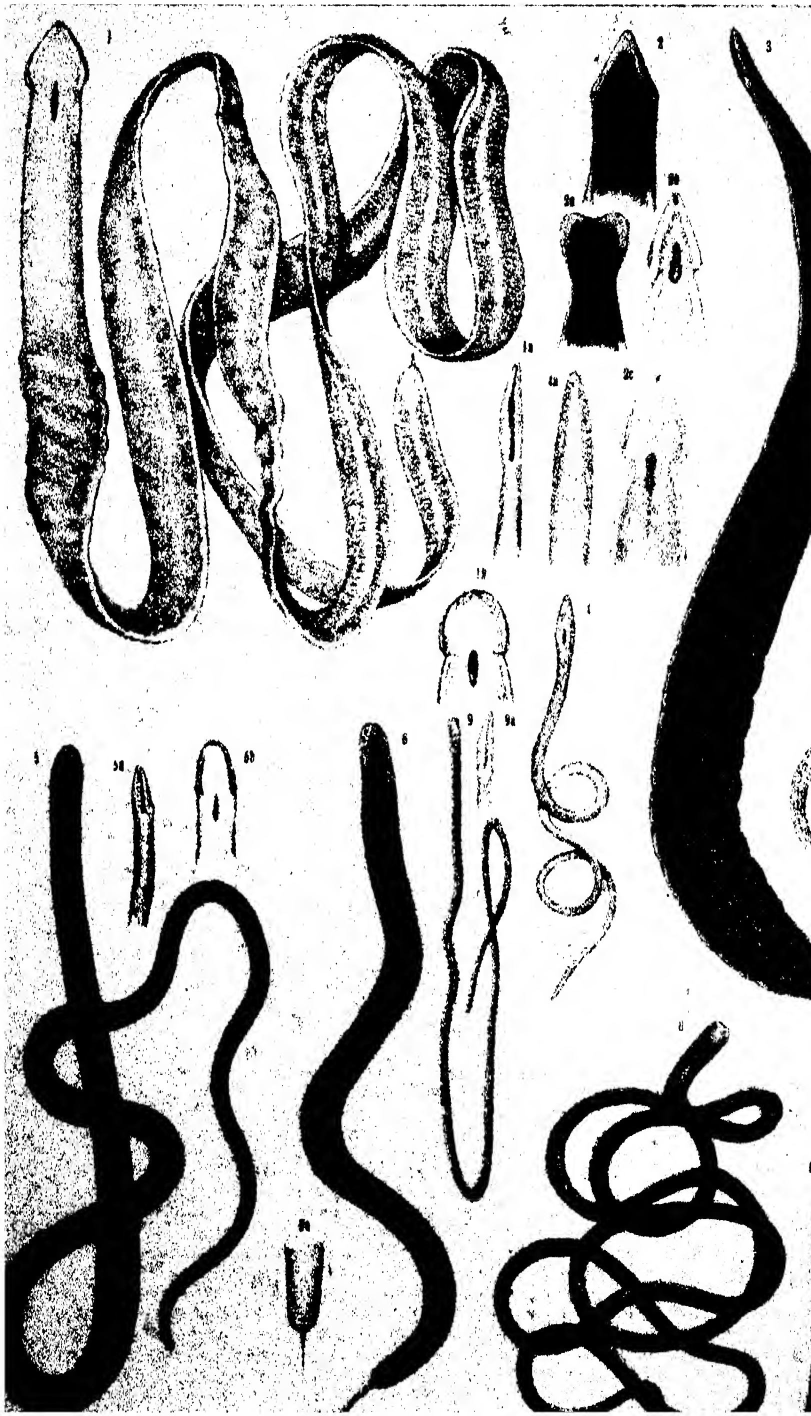
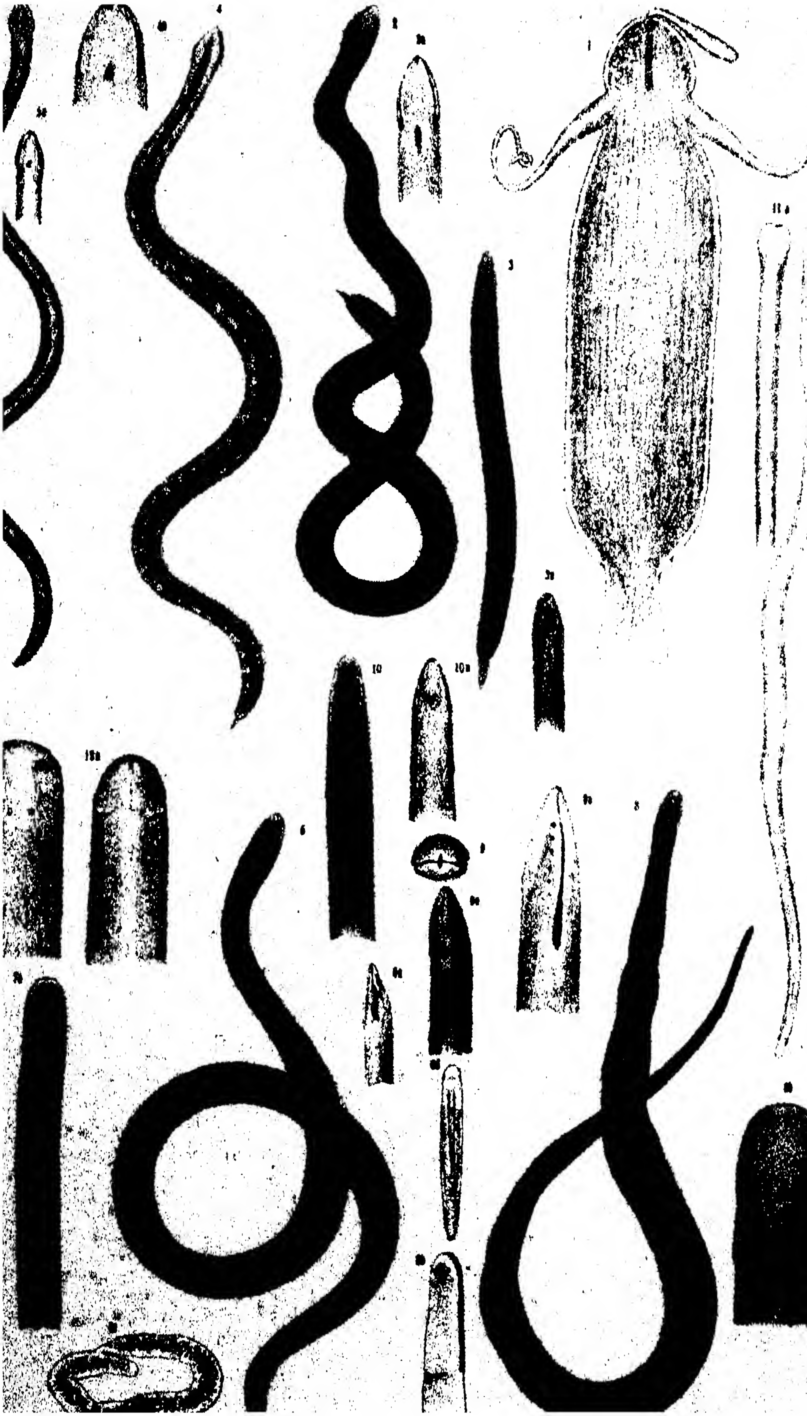
6b
5
5c
6c

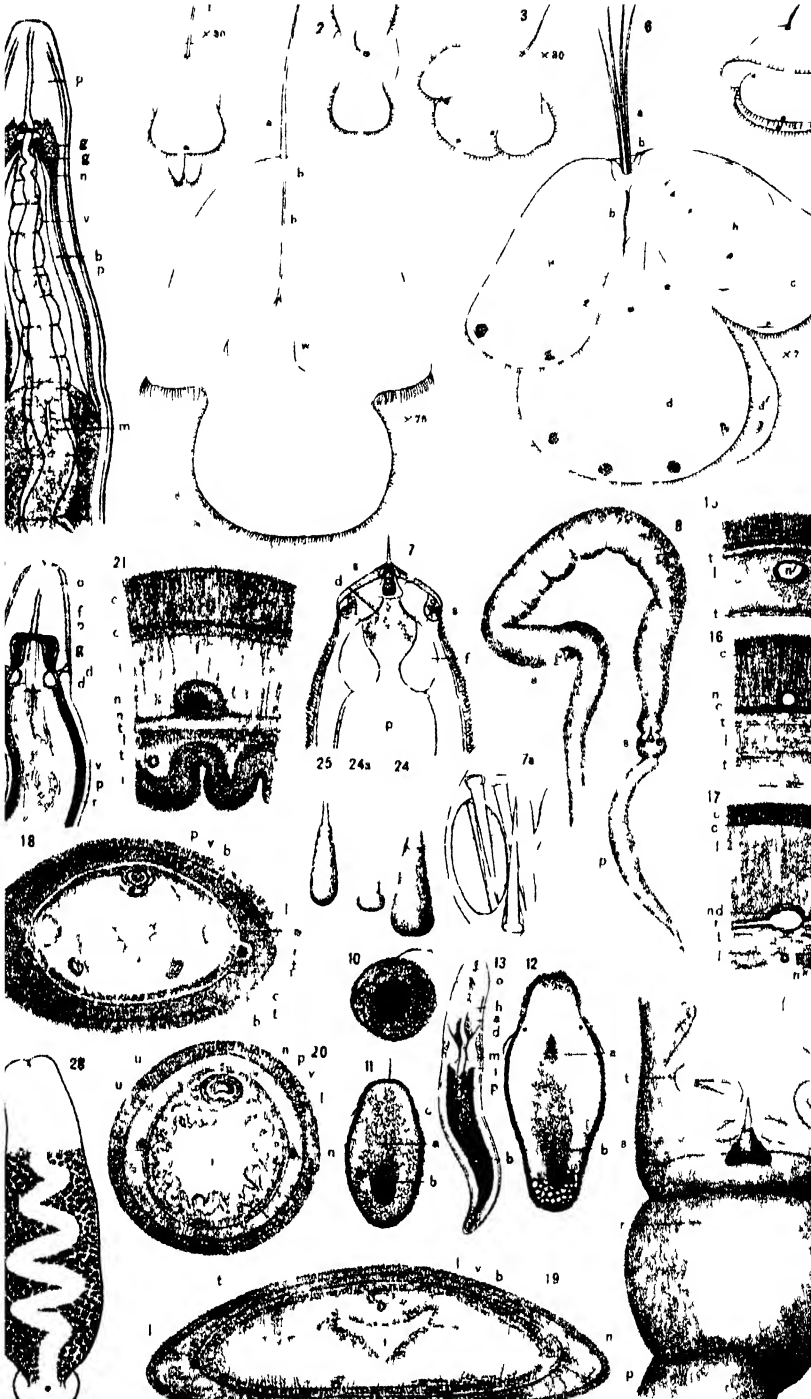





4
1
5
6a
2
6


1
2
3
5
6
9
9a
10





1
2
3
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6
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7a
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10
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12
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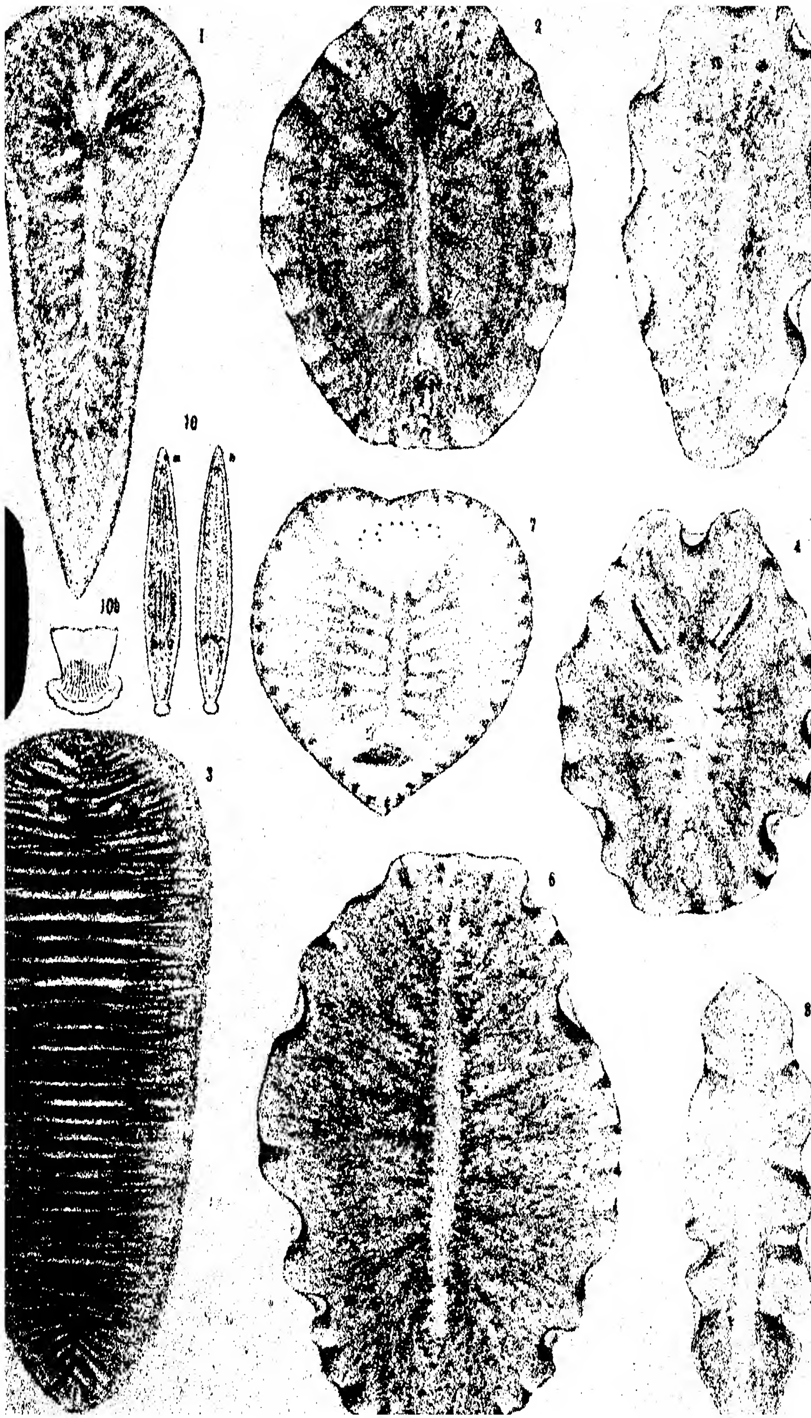
24a
25
28


1
2
10
a
b
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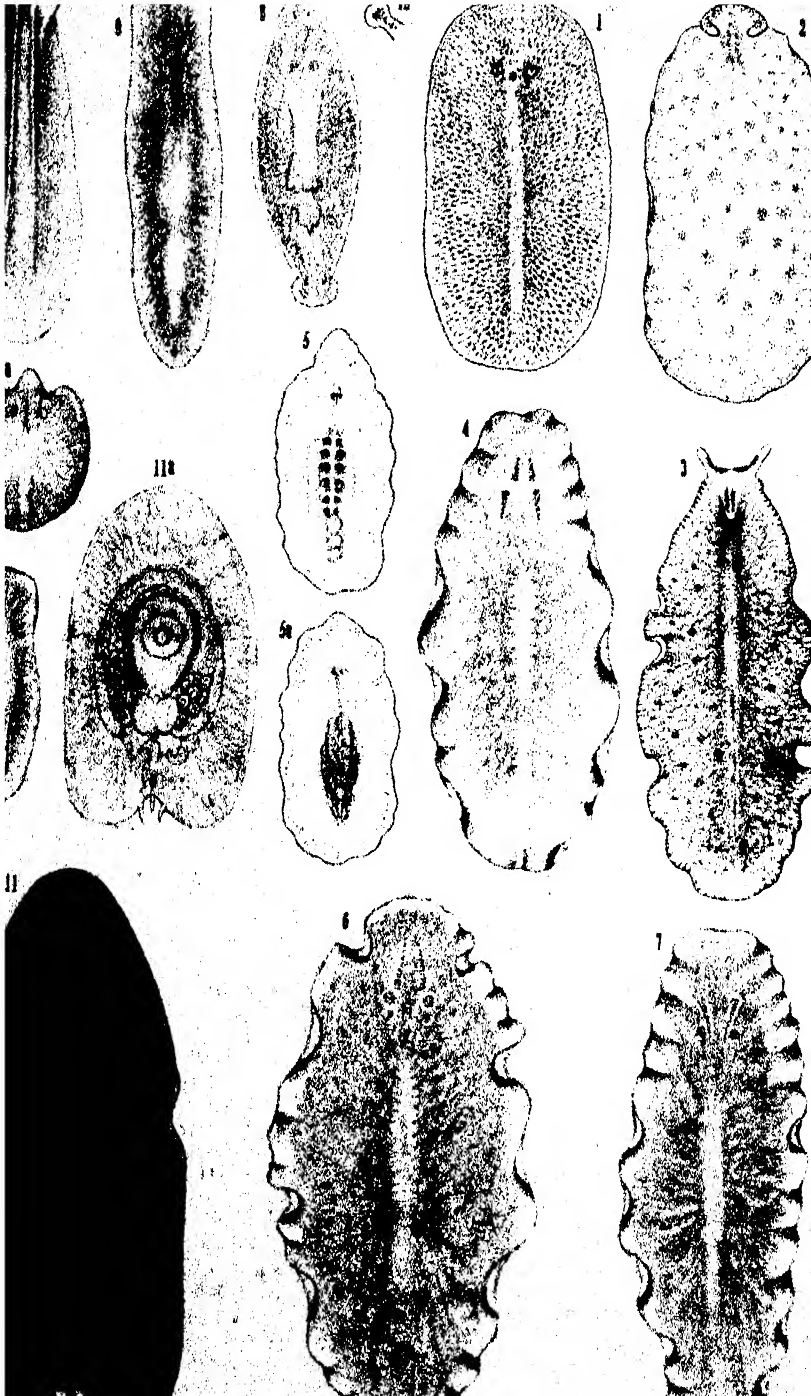
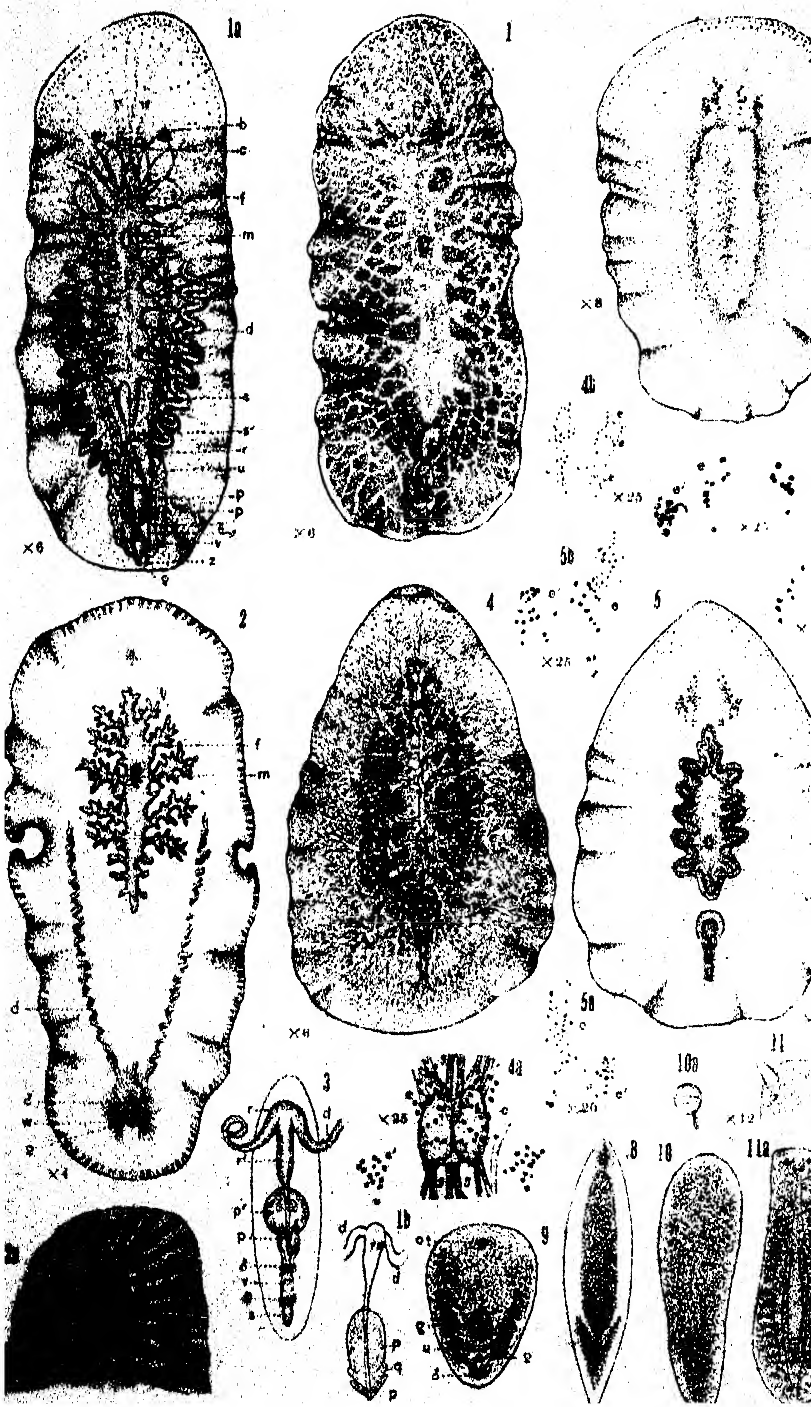
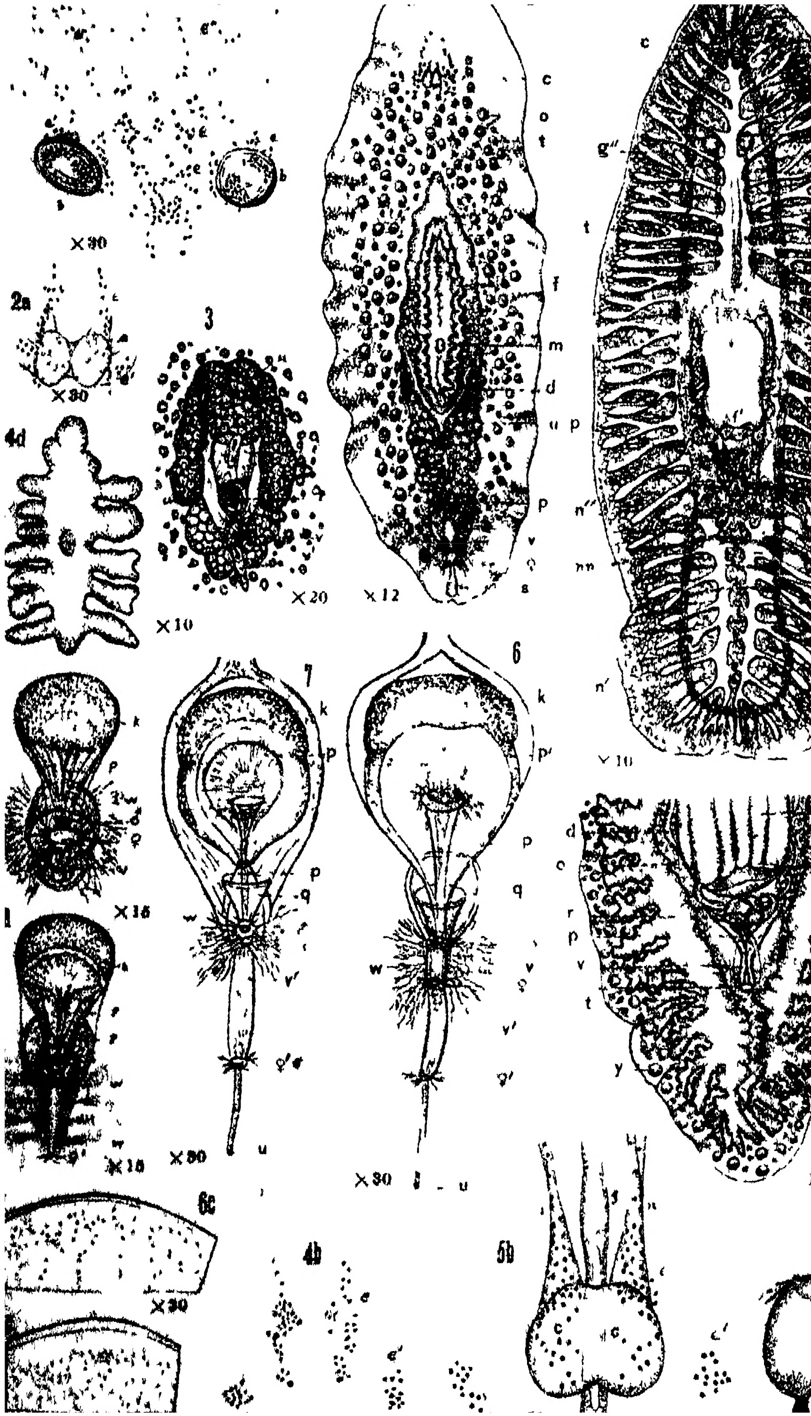

1
2
3
4
5
5a
6
7
11
11a


1a
1
×6
2
4
3
4a
4b
5
5a
5b
1b
9
8
10
10a
11
11a
×25
×12


×30
2a
×30
3
4d
×10
×20
×12
×10
7
6
×15
×30
×30
6c
×30
4b
5b